METALLURGIA

THE BRITISH JOURNAL OF METALS

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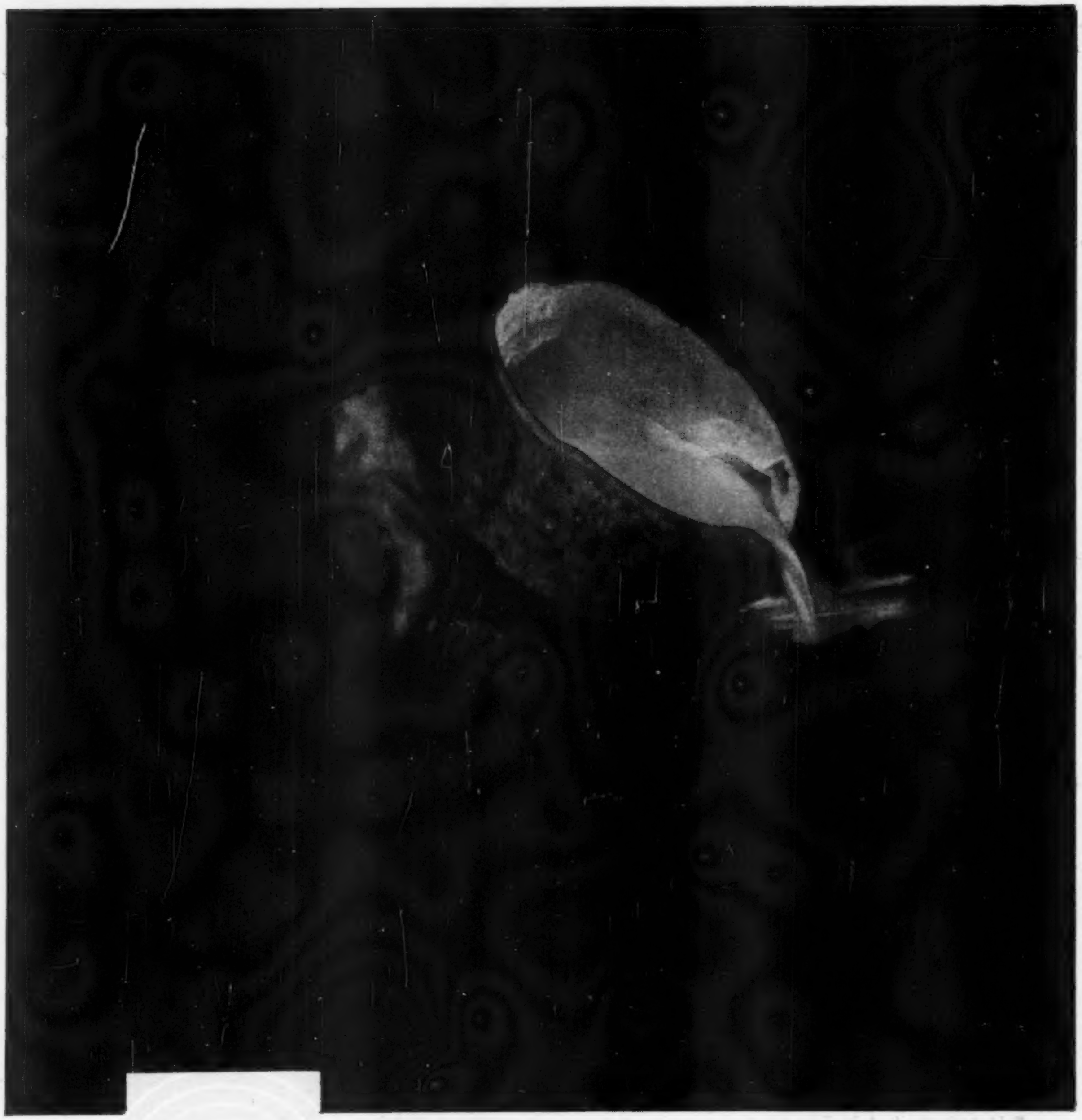

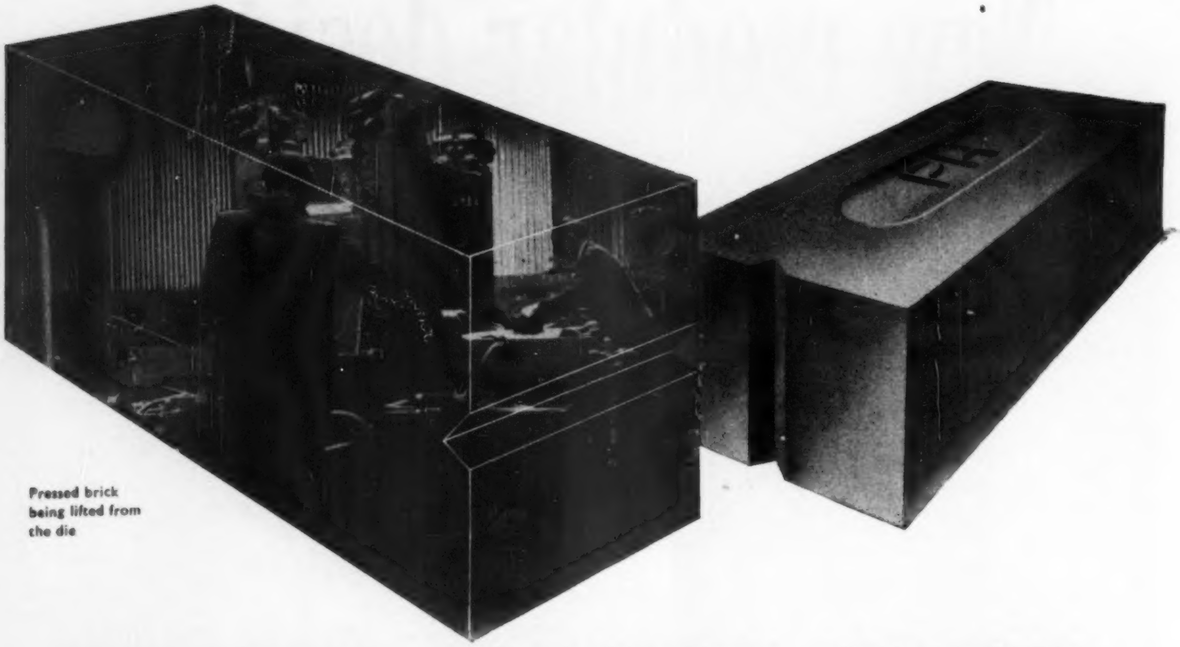

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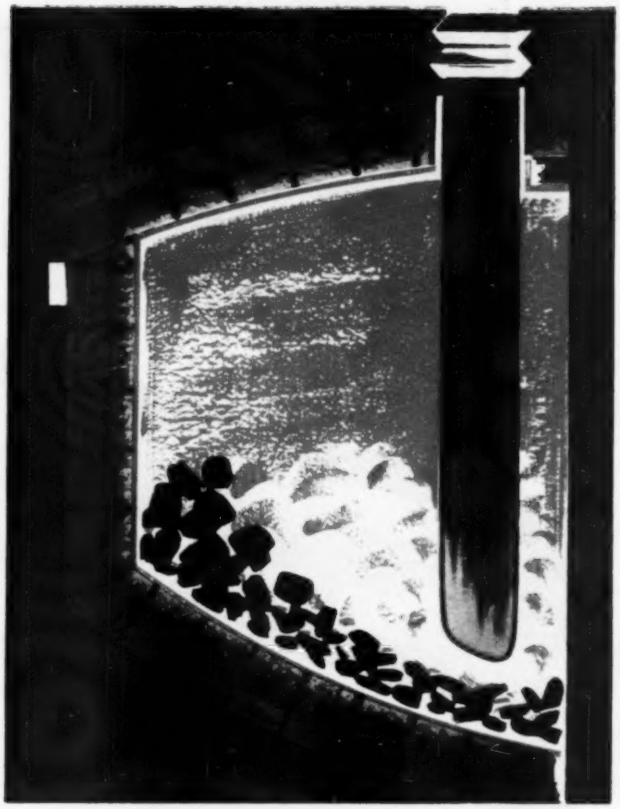

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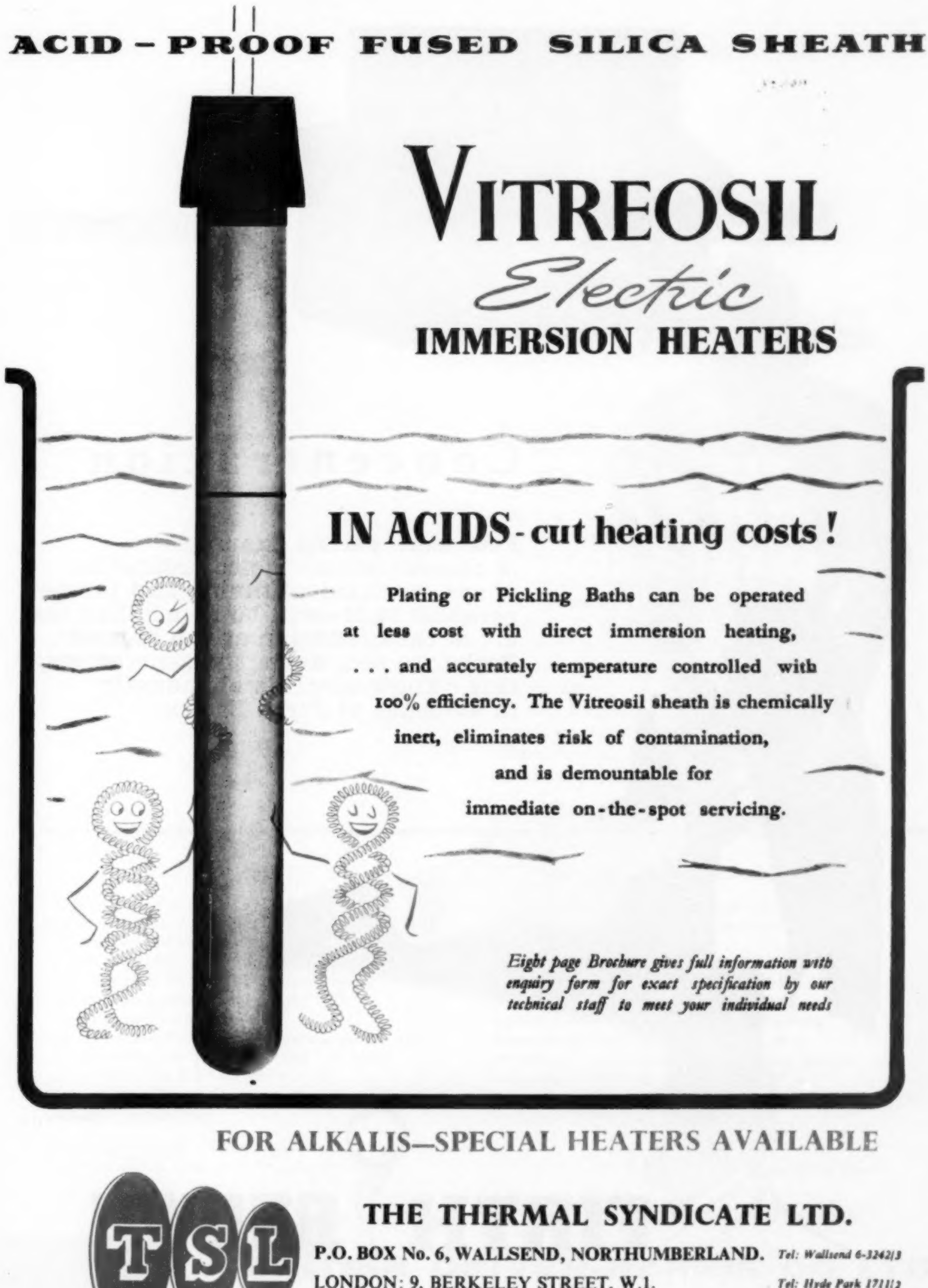
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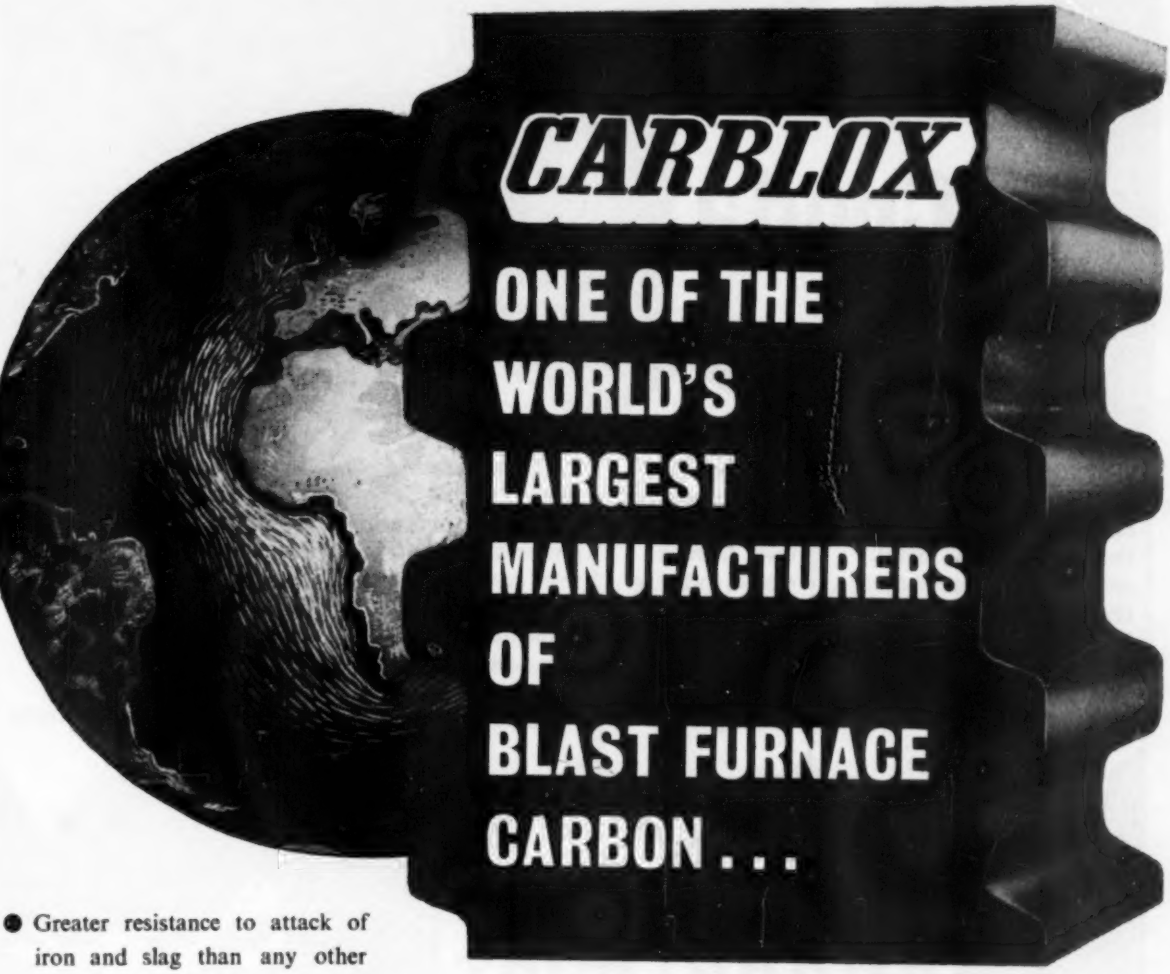

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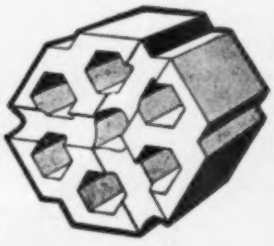

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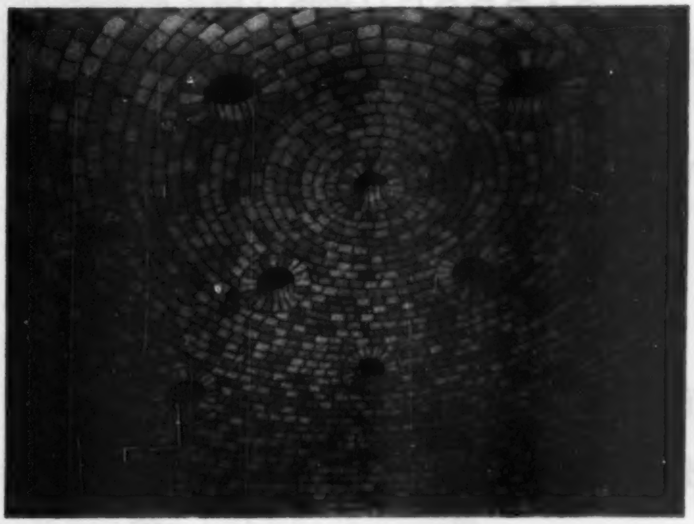

Five years ago we began rebuilding the round down-draught kilns of The Morgan Crucible Co. Ltd. at Battersea in MI. 28 — a hot-face insulating brick of low thermal capacity that was then comparatively new. The roof of one of these furnaces immediately after installation is shown in the first picture.

. . . (MI. 28 bricks)

. . . and like it

The output of these kilns, lined with MI. 28, was considerably greater than their firebrick counterparts, because the low heat-storage of the lining shortened both heating and cooling periods. This, in fact, was the principal reason for the change-over. What we were not so sure of at that time was the life of these linings. We would hardly have dared to expect anything as good as we got. The second picture shows the same roof after *five years'* service. So far as we can see it is good for at least another five years and probably longer.

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PROPAGAS PROPANE

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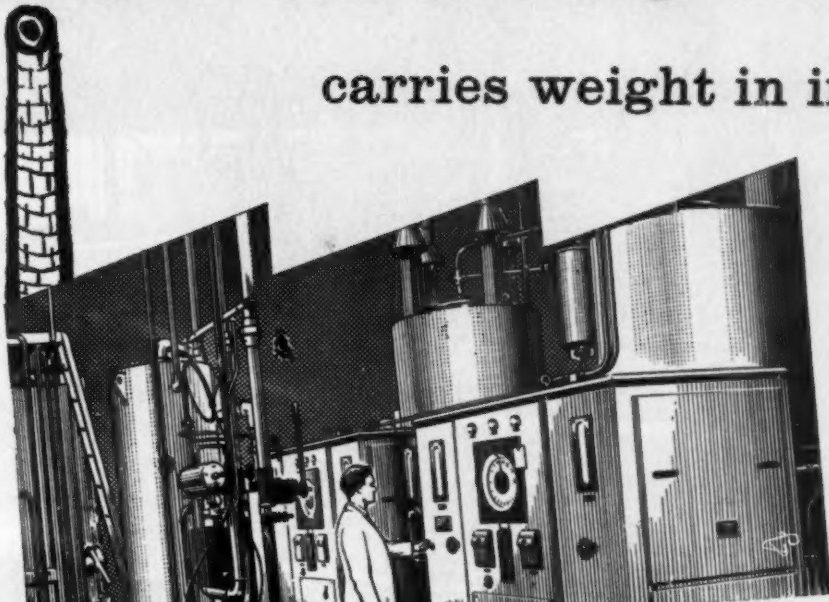

Birlec Generators producing special atmospheres for gas carburizing at E.N.V. Engineering Company Limited.

Propane and Butane are now available to industry from the great British refineries of the Shell, Eagle and BP Groups. They are petroleum gases delivered and stored as liquids under moderate pressure.
Propane supplied by Shell-Mex and B.P. Gases Limited provides industry not only with a high calorific value fuel gas (approximately 2,500 B.t.u./cubic foot) but also with an excellent medium for the production of special furnace atmospheres.
It is widely used for gas carburizing, carbonitriding and bright annealing of ferrous and non-ferrous metals.
'Bottogas' Butane is used as a fuel for fork lift trucks and for many other specialised applications.

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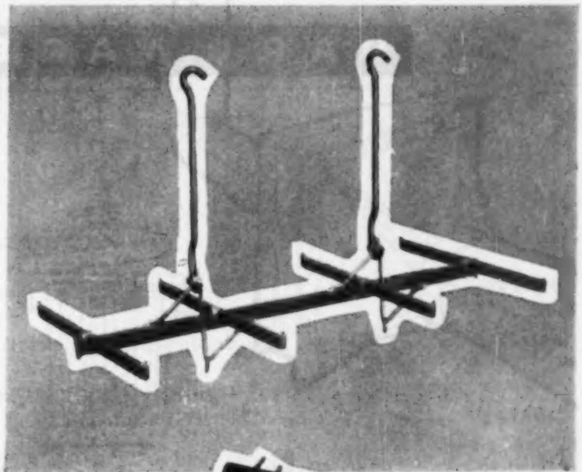
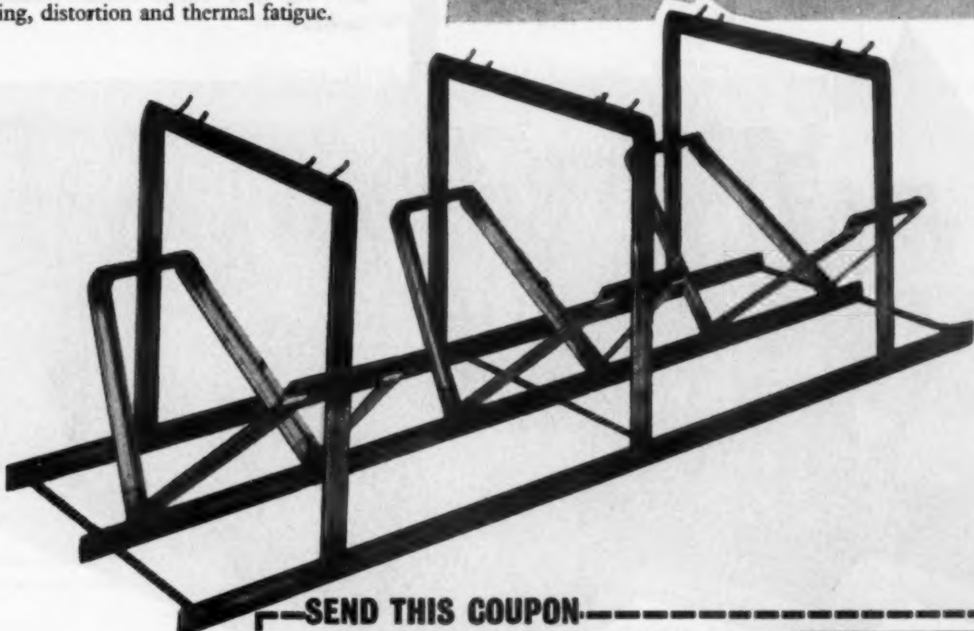
Cutting the cost of Vitreous Enamelling

Nimonic HEAT-RESISTING ALLOYS



Keeping heat loss to a minimum in vitreous enamelling is particularly important in the highly competitive domestic equipment industry. To help reduce production costs, the perrits, hangers, flight bars and other furnace furniture used to support components during firing, are fabricated in *Nimonic 75 and *Incoloy DS heat-resisting alloys.

The excellent strength of these alloys over the whole range of firing temperatures—about 780-860°C.—permits fabrication of robust long-lasting units of thinner section. Their low heat capacity reduces heat loss and firing time in the furnace, while their light weight results in easier handling and reduced loads on conveyor systems. Fabrication presents no difficulties and the alloys have excellent resistance to scaling, distortion and thermal fatigue.



The Nimonic 75 alloy perrit shown here is designed to carry six washing-machine tops. The fabricated flight bar above is of Incoloy DS. Both units were produced by Ferro Enamels Ltd., of Wolverhampton.

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INCORPORATING THE METALLURGICAL ENGINEER

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LABORATORY METHODS SUPPLEMENT

METALLURGIA

THE BRITISH JOURNAL OF METALS

INCORPORATING THE "METALLURGICAL ENGINEER"

June, 1960 Vol. LXI. No. 368

Training of Metallurgists

IN the course of his recent presidential address to the Institution of Metallurgists, Mr. W. E. Bardgett referred to the expansion in metallurgical activities at present taking place. "Even at its present advanced stage of growth," he said, "Metallurgy is likely to suffer from growing pains, and we should seek to find out where strengthening and stimulus might be applied. With this in mind, there are many branches of activity which we can consider, but training and metallurgical facilities and effort are worthy of special thought." Mr. Bardgett's comments on the subject of training are presented here without comment.

"The Institution is very active and is doing good work in the field of education but this must be supplemented by training, and by this we mean organised experience in the field of the practising metallurgist. Our interest, as far as training is concerned, applies to university graduates who are educated but not trained, and to school leavers who require both education and training, which run concurrently.

"For many years it was general practice to engage school leavers and employ them in a research laboratory, works laboratory or directly in the works, leaving them to gain such experience as might come their way, and to acquire metallurgical backing by evening study. The training received was more a question of picking things up, emphasis being on what to do rather than why it is done, and was dependent on the changes in occupation which happened by chance and not design. Similarly, it has often been the practice, and still is in some cases, to engage graduates and place them immediately in metallurgical tasks, the employer forgetting that the graduate, though educated, is not trained technologically. This undesirable approach was undoubtedly motivated by a short-sighted economic outlook, employees of most branches of science being required to give an immediate return for their salary. To give organised training meant little immediate return. In spite of the difficulties facing the young technologist, or potential technologist, many have succeeded in attaining high standards of technical achievement and high places in industrial development. This inefficient utilisation of junior people's time is out of keeping with the demands of industry for greater numbers of well-qualified and trained technologists, and must be removed through sheer economic necessity. Further, we have that important objective of raising the status of the metallurgist and must be deeply concerned with this.

"In certain industries there are centralised training organisations, but the policy and detailed planning must be carried out by individual firms. No matter who may be responsible for the planning, the senior metallurgists must have an important voice in interpreting the needs of the apprentice or trainee. Each metallurgist has a responsibility to his juniors in providing every possible facility for expanding their activities and experience in a planned arrangement. I feel sure we can all do a great deal more than we have done in the past to enhance the status of our fellow metallurgists within our own immediate circle.

"Many firms have well-organised training schemes, but even in some of these perhaps more can and should be done to provide the metallurgists with more and wider experience in basic metallurgical work and up-to-date techniques, so that they are equipped to deal more scientifically with problems. In generalising, one lays oneself open to particular criticism, but some degree of generalisation cannot be escaped in dealing with such a broad subject as training. However, if we endeavour to think constructively, we might make at least some better contribution to the future welfare of metallurgists. To make training effective, it must be divorced from the idea of immediate profitable work, otherwise we are only partly dealing with the problem. There are a great many metallurgical operations which are repetitive and these in general are not jobs for metallurgists at all. These are the jobs which we used to train young people to do and were content to leave them doing for years—enough to break the heart of any junior aspiring to be a metallurgist. Normally they graduated from one job to another but, thank goodness, most of them had their satisfaction from endeavouring to reach the goal of a qualification. It is probably the experience of many of us that a bright junior is quickly frustrated when called upon to do repetitive work which provides very limited experience and requires no particular intellectual capacity. Many jobs of this type which arise in both works and research laboratories are, however, essential for the successful prosecution of scientific investigations. A satisfactory solution to this problem is to be found in employing older people who may have no special training but who have sufficient intelligence to learn in a short time all that is required to carry out specific operations, appreciating not only what to do but why it is done in a certain way. Such people may even contribute constructively to improvement in techniques. Experience has shown that there is no difficulty in filling posts of this type very successfully. They have a certain attraction, without frustration, for a particular type of man who is satisfied merely to continue doing a routine job. Even in the case of qualified and trained metallurgists, there may be opportunities to replace them by less skilled assistants so that they may be employed in applying their knowledge and training to the greater advantage of themselves, their employers, and the profession.

"An approach to metallurgical training can only be referred to on a relatively broad basis, since the immediate sphere of activity of any metallurgist is peculiar to the organisation in which he works. Facilities

for training will accordingly differ, but the road to our objectives should form a basic pattern. In certain cases, initial specialised training may be without an alternative, and in such cases should only concern qualified people; in particular, graduates.

"We are especially concerned with school leavers who require both educating and training. These are the potential metallurgists whose training requires special care and attention. One cannot accept that a youth at the age of sixteen will necessarily be firm in his initial choice of metallurgy as a career. Consequently, the first two years should be spent, as far as possible, on a very general apprenticeship, during which time he moves from one department to another, gaining as he goes an accurate idea of the scope of each branch of technology. This period should coincide with a period of his education where he is taking a national certificate course in basic subjects. He may at this stage have reached a point where he can decide whether he desires to adopt metallurgy as a career. If so, then he should join the metallurgical group of his company and his future training should be planned within this group. During this period he should study for a Higher National Certificate in metallurgy, aiming for the Licentiate examination.

"There will undoubtedly be cases of juniors who might attain Ordinary National Certificate standard but who are not capable of continuing to H.N.C. Clearly, if this is adjudged to be the case, the person concerned should be encouraged to aim for the laboratory technician grade or other suitable alternative.

"It must be accepted that organised training is as important for a graduate as for a junior metallurgist, but the course will be different in both design and extent. One should aim for an 'apprenticeship' period of about two years, at the end of which the graduate will decide whether his interests lie in research or in works metallurgy. The major portion of his training should be in the research laboratory, under the supervision of senior metallurgists who are doing metallurgical work, as opposed to administering such work. He should, during his training, have an opportunity to study the detailed activities of the works metallurgists in relation to works processes, since we are so often concerned with problems relating to materials which may be associated with a number of factors. These may be raw materials, method of manufacture, composition, heating, rolling, final heat treatment and structure. At the end of his training he can be accepted as a senior metallurgist, capable of handling large problems on his own.

"In outlining my thoughts on an approach to training, I have been fully conscious of the great divergence of facilities, but the purpose of what I have said is to try and stimulate action where necessary in this important aspect of our objectives.

"Apart from the question of providing larger numbers of trained and qualified metallurgists to meet the present and future normal demands, my general experience is that there is often a tendency to limit metallurgical effort in works laboratories to an undesirably low level. We have faith in the value of the contribution which science can make and a little empire building might, in certain cases, be justified. However, to think in terms of expansion means that we must also be planning recruitment and training. Alternatively, we have to rely on obtaining increased technical assistance by advertising, and with such a procedure one surely has a feeling of guilt, knowing that success means someone else's loss; in fact, a loss to a number of organisations or firms who fall into the line of supply for this one move. We require to be fully alive to the necessity for planning to meet our requirements of trained and qualified personnel arising from retirement and expansion."

D.S.I.R. Grants for Research

In 1959, the Department of Scientific and Industrial Research increased the number of grants to universities and technical colleges for researches in every field of science except mathematics.

In the field of metallurgical research a break-through of great significance has recently been made, using electron-transmission microscopy. This has been achieved by workers at the University of Cambridge. It is now possible to follow by cine-techniques the arrangement and motion of dislocations when a metal foil is strained to breaking point. Microstructures virtually down to the atomic scale can be seen for the first time. It can also be observed, for instance, what happens when a pure metal is suddenly cooled from a high temperature, and how nuclear radiation damages the crystal structure. This new technique of transmitting through a thin metal foil offers a great opportunity to understand thoroughly how the engineering properties of solids result from atomic structure and properties. Workers in this field include Dr. P. B. Hirsch of the Cavendish Laboratory, whose researches are supported by a D.S.I.R. grant of £18,730, and Professor A. H. Cottrell, of the Department of Metallurgy, Cambridge, who was awarded a grant of £15,000 for electron microscopical study of metallurgical problems.

A research grant of particular local significance has been awarded to Sheffield University for work on transformations in steels. The grant, worth £36,000, enables Professor A. G. Quarrell and his colleagues in the Department of Metallurgy to purchase new apparatus, offering greatly improved techniques in the study of the structure, composition and properties, both microscopic and macroscopic, of steels. The research programme includes a study of the fracture surfaces of various cast steels, a more precise determination of the role of alloying elements, the effect of cooling rate and the influence of "trace elements." Structural changes during the working of iron-manganese-carbon alloys, creep properties, the constitution of slags and slag-metal reactions and a host of other research problems of significance to the steel industry are also being undertaken.

Acme-Efco, Ltd.

A new company, known as Acme-Efco, Ltd., has been formed by the Acme Manufacturing Co., of Detroit, specialists for over fifty years in automatic polishing machine manufacture, and Electro-Chemical Engineering Co., Ltd., well-known for automatic electroplating machines and plating processes. Acme-Efco, Ltd., will be concerned with the sales, manufacture, installation and servicing of automatic and semi-automatic polishing and buffing machines in this country. The company will be located at Sheerwater, Woking, Surrey (telephone Woking 5222). The sales manager of the new company is Mr. R. G. Hughes.

Non-Ferrous Research Progress

Research Association's Annual Report

THE fortieth Annual General Meeting of The British Non-Ferrous Metals Research Association, held at the Savoy Hotel, London, on May 11th, was the first to be presided over by MR. F. C. BRABY, M.C., D.L., who took over Chairmanship of Council from DR. MAURICE COOK, C.B.E., in January. The continued interest and help of Dr. Cook in the work of the Association is assured by his co-option to Council. Elections to the Council of the Association at the Annual General Meeting included: MR. L. R. CARR, M.P. (John Dale, Ltd.); MR. L. ROTHERHAM (Central Electricity Generating Board); MR. R. D. BURN (The British Metal Corporation, Ltd.); MR. S. E. CLOTWORTHY, C.B.E. (Northern Aluminium Co., Ltd.); MR. A. H. CARMICHAEL (Cable Makers Association); MR. G. HUNT (High Duty Alloys, Ltd.); and DR. N. P. INGLIS (I.C.I., Ltd.). Of these, the first two have served for some time as Co-opted Members of Council, while Mr. Burn and Mr. Clotworthy were appointed during the year to fill casual vacancies.

During 1959, further contributions towards the new laboratory block opened a year ago brought the total from members plus D.S.I.R. grant earned to £107,500, a substantial proportion of the £130,000 which the expansion has cost. The expanded research programme, which the extra laboratory space and increased industrial support allows, necessitates an increase in staff. Seven additional qualified scientists were engaged in 1959, bringing the total staff to just over 170, and recruitment of more staff is proceeding as scientists of the right calibre can be found.

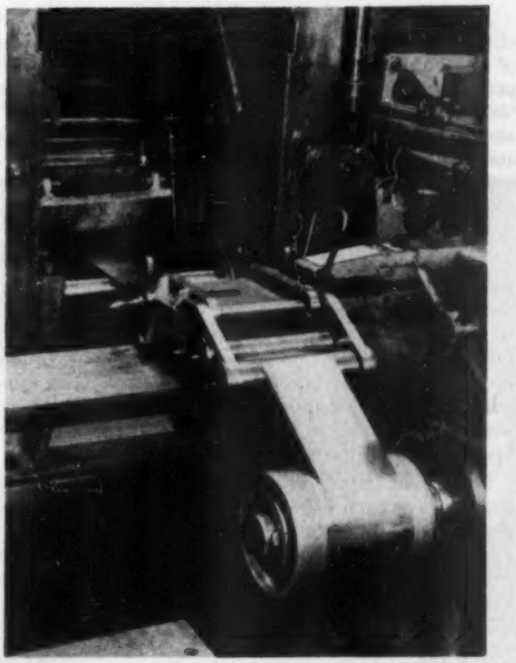
Among the new researches listed in the Association's Annual Report are investigations into the prevention of air pollution; effluent treatment; nickel additions to gunmetal; preheating atmospheres for copper cakes and wire bars; springiness in copper wire; hard spots in cast and extruded brasses; butt welding of high-conductivity copper and corrosion cracking of copper alloys. In the light alloy field new researches include directional properties of medium strength alloys and tests for serviceability of bright anodised aluminium. In the nuclear energy field there are new researches on the protection of niobium by plating; absorption of hydrogen by metals; and intercrystalline fissuring and cavitation. A fundamental study of the oxidation of zinc has also been started, and a new study of cobalt additions to nickel plating solutions.

Research Progress

Some of the more important developments in the research work mentioned in the 1959 Annual Report are outlined in the following sections.

Foundry Work

For some time research has been in progress aimed at bringing about a more scientific approach to the running, gating and feeding of castings, since failure to appreciate the principles is the root cause of the greater part of foundry scrap and poor castings. The work on gunmetals has recently been completed with demonstrations of the application of the principles found in the research to the production of a flanged half bearing and a water valve body. Parallel work is continuing with aluminium bronze.



A production version of the B.N.F. roller stretcher in operation on a brass strip mill.

The results of work on the relationship between the constitution of the gunmetals and the properties and casting characteristics was issued during 1959 as a pamphlet "Gunmetals—Choosing the Best," about 6,000 copies of which were distributed through member firms. The work led to the development of the "B.N.F. Gunmetal"—an alloy giving more uniform properties in thin and thick sections and having excellent pressure tightness. Its inclusion in the new British Standard for copper alloy castings has been recommended. It is also hoped that an improved test bar for gunmetals recommended on the basis of extensive laboratory and co-operative foundry trials will be accepted by B.S.I.

Investigations into the casting of high-silicon aluminium alloys has been the main feature of the foundry programme for the aluminium industry. These alloys are being considered by the motor industry for cylinder blocks and other parts where their lightness, low expansion and good wear resistance are attractive features. Ways of improving the stress corrosion resistance of the high strength casting alloys such as L53 have also been examined.

Wrought Light Alloys

The basic causes of the difficulties of ensuring adequate transverse properties in high strength alloys of the

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D.S.I.R. Grants for Research

In 1959, the Department of Scientific and Industrial Research increased the number of grants to universities and technical colleges for researches in every field of science except mathematics.

In the field of metallurgical research a break-through of great significance has recently been made, using electron-transmission microscopy. This has been achieved by workers at the University of Cambridge. It is now possible to follow by cine-techniques the arrangement and motion of dislocations when a metal foil is strained to breaking point. Microstructures virtually down to the atomic scale can be seen for the first time. It can also be observed, for instance, what happens when a pure metal is suddenly cooled from a high temperature, and how nuclear radiation damages the crystal structure. This new technique of transmitting through a thin metal foil offers a great opportunity to understand thoroughly how the engineering properties of solids result from atomic structure and properties. Workers in this field include Dr. P. B. Hirsch of the Cavendish Laboratory, whose researches are supported by a D.S.I.R. grant of £18,730, and Professor A. H. Cottrell, of the Department of Metallurgy, Cambridge, who was awarded a grant of £15,000 for electron microscopical study of metallurgical problems.

A research grant of particular local significance has been awarded to Sheffield University for work on transformations in steels. The grant, worth £36,000, enables Professor A. G. Quarrell and his colleagues in the Department of Metallurgy to purchase new apparatus, offering greatly improved techniques in the study of the structure, composition and properties, both microscopic and macroscopic, of steels. The research programme includes a study of the fracture surfaces of various cast steels, a more precise determination of the role of alloying elements, the effect of cooling rate and the influence of "trace elements." Structural changes during the working of iron-manganese-carbon alloys, creep properties, the constitution of slags and slag-metal reactions and a host of other research problems of significance to the steel industry are also being undertaken.

Acme-Efco, Ltd.

A new company, known as Acme-Efco, Ltd., has been formed by the Acme Manufacturing Co., of Detroit, specialists for over fifty years in automatic polishing machine manufacture, and Electro-Chemical Engineering Co., Ltd., well-known for automatic electroplating machines and plating processes. Acme-Efco, Ltd., will be concerned with the sales, manufacture, installation and servicing of automatic and semi-automatic polishing and buffing machines in this country. The company will be located at Sheerwater, Woking, Surrey (telephone Woking 5222). The sales manager of the new company is Mr. R. G. Hughes.

Non-Ferrous Research Progress

Research Association's Annual Report

THE fortieth Annual General Meeting of The British Non-Ferrous Metals Research Association, held at the Savoy Hotel, London, on May 11th, was the first to be presided over by MR. F. C. BRABY, M.C., D.L., who took over Chairmanship of Council from DR. MAURICE COOK, C.B.E., in January. The continued interest and help of Dr. Cook in the work of the Association is assured by his co-option to Council. Elections to the Council of the Association at the Annual General Meeting included: MR. L. R. CARR, M.P. (John Dale, Ltd.); MR. L. ROTHERHAM (Central Electricity Generating Board); MR. R. D. BURN (The British Metal Corporation, Ltd.); MR. S. E. CLOTWORTHY, C.B.E. (Northern Aluminium Co., Ltd.); MR. A. H. CARMICHAEL (Cable Makers Association); MR. G. HUNT (High Duty Alloys, Ltd.); and DR. N. P. INGLIS (I.C.I., Ltd.). Of these, the first two have served for some time as Co-opted Members of Council, while Mr. Burn and Mr. Clotworthy were appointed during the year to fill casual vacancies.

During 1959, further contributions towards the new laboratory block opened a year ago brought the total from members plus D.S.I.R. grant earned to £107,500, a substantial proportion of the £130,000 which the expansion has cost. The expanded research programme, which the extra laboratory space and increased industrial support allows, necessitates an increase in staff. Seven additional qualified scientists were engaged in 1959, bringing the total staff to just over 170, and recruitment of more staff is proceeding as scientists of the right calibre can be found.

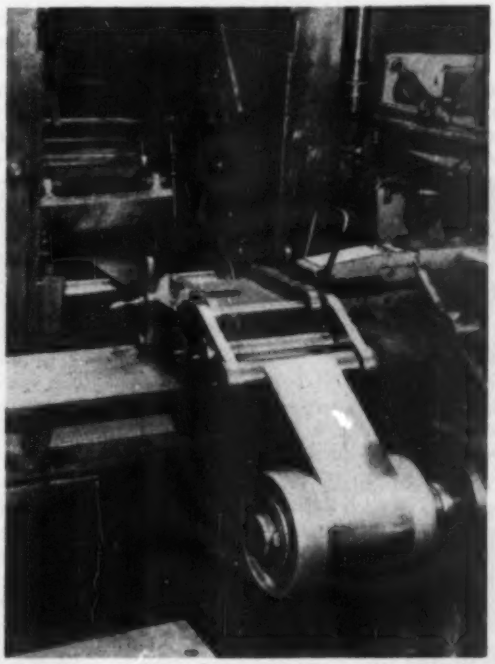
Among the new researches listed in the Association's Annual Report are investigations into the prevention of air pollution; effluent treatment; nickel additions to gunmetal; preheating atmospheres for copper cakes and wire bars; springiness in copper wire; hard spots in cast and extruded brasses; butt welding of high-conductivity copper and corrosion cracking of copper alloys. In the light alloy field new researches include directional properties of medium strength alloys and tests for serviceability of bright anodised aluminium. In the nuclear energy field there are new researches on the protection of niobium by plating; absorption of hydrogen by metals; and intercrystalline fissuring and cavitation. A fundamental study of the oxidation of zinc has also been started, and a new study of cobalt additions to nickel plating solutions.

Research Progress

Some of the more important developments in the research work mentioned in the 1959 Annual Report are outlined in the following sections.

Foundry Work

For some time research has been in progress aimed at bringing about a more scientific approach to the running, gating and feeding of castings, since failure to appreciate the principles is the root cause of the greater part of foundry scrap and poor castings. The work on gunmetals has recently been completed with demonstrations of the application of the principles found in the research to the production of a flanged half bearing and a water valve body. Parallel work is continuing with aluminium bronze.



A production version of the B.N.F. roller stretcher in operation on a brass strip mill.

The results of work on the relationship between the constitution of the gunmetals and the properties and casting characteristics was issued during 1959 as a pamphlet " Gunmetals—Choosing the Best," about 6,000 copies of which were distributed through member firms. The work led to the development of the " B.N.F. Gunmetal "—an alloy giving more uniform properties in thin and thick sections and having excellent pressure tightness. Its inclusion in the new British Standard for copper alloy castings has been recommended. It is also hoped that an improved test bar for gunmetals recommended on the basis of extensive laboratory and co-operative foundry trials will be accepted by B.S.I.

Investigations into the casting of high-silicon aluminium alloys has been the main feature of the foundry programme for the aluminium industry. These alloys are being considered by the motor industry for cylinder blocks and other parts where their lightness, low expansion and good wear resistance are attractive features. Ways of improving the stress corrosion resistance of the high strength casting alloys such as L53 have also been examined.

Wrought Light Alloys

The basic causes of the difficulties of ensuring adequate transverse properties in high strength alloys of the

D.T.D.683 type, which have been under examination for some time, have suggested further studies of manufacturing procedure and these have been followed up during the past year with significant results. Various ways of protecting these high strength alloys from corrosive atmospheres using sprayed metal coatings are under examination.

A large programme of work on the fatigue properties of medium strength structural light alloys occupies much of the equipment in the new fatigue laboratory. The programme is aimed at providing basic design information for the better utilisation of aluminium alloys in road and rail transport. In addition, studies of fretting fatigue and of anti-fretting media of interest to the aircraft industry are in progress.

Wrought Copper Alloys

The roller-stretcher developed in the course of the research on the rollability of copper alloys has been demonstrated during the year to many members. This is a device for continuously stretching metal strip to bring about relief of internal stresses. Its most important application is in the removal of one of the main causes of edge bowing in strip slit into narrow widths by rotary shears. Two or three machines are already in commercial operation and others are being built.

Bright annealing atmospheres for high conductivity copper have been exhaustively studied in order to define permissible hydrogen contents to avoid embrittlement of the copper as a result of the " gassing " reaction. Further work on bright annealing being pursued at present is aimed at determining the circumstances which cause coils of wire and strip to stick together or to stain during annealing.

Process Control

Considerable progress has been made with the application of the X-ray fluorescence method of analysis to the accurate determination of major alloying constituents in copper alloys and some other non-ferrous metals, both with the Association's own X-ray spectrometer and also with an automatic commercial instrument loaned for demonstration purposes. It has been shown how inter-element effects can be overcome, thus greatly increasing the scope of the method. Largely as a result of this work and the demonstrations that have been given at the laboratories, instruments are being installed in industry for routine analytical control.

Other researches on instrumentation have been concerned with radiation pyrometry as applied to aluminium alloys, and with the eddy current testing of tubes for minor manufacturing defects. Both projects are reaching the industrial development stage and through the D.S.I.R. " Special Assistance " scheme a new member of staff has been engaged specifically to help with industrial demonstrations of these and other process control instruments, such as the B.N.F. plating gauge referred to later.

Corrosion Studies

A new brass alloy developed in the course of long range research on condenser tubes has been produced on an industrial scale for service trials in ships and in power stations. Laboratory tests have shown it to have a better performance in polluted waters than existing condenser tube alloys.

Much of the corrosion work continues to be concerned with the use of non-ferrous metals in domestic water supplies. Good progress has been made with identifying the water compositions causing the dezincification of hot stamped brass fittings experienced in some parts of the country, and similar laboratory studies with synthetic waters are yielding useful information about the behaviour of aluminium in water supplies and industrial cooling systems. Basic studies of scale formation in supply waters have thrown a good deal of light on the reasons for the premature failures of galvanized tanks experienced in some hot water installations and enabled better tests to be devised for assessing the performance of experimental coatings.

Plating

The results of the most important work carried out in the Metal Finishing Section during the year were recently published in a Development Report " Better Plating on Die Castings " (for which there has been a considerable demand). This work shows that thicker crack-free chromium coatings applied by modifications to the normal plating procedure defined in earlier work on chromium plating can improve very substantially the corrosion resistance of plated zinc alloy die castings. Considerable evidence is provided in the report on the better performance on outdoor exposure tests—some in highly corrosive atmospheres—of castings so treated.

This work on die castings has confirmed the importance of an adequate thickness of nickel under the chromium, emphasising the need for a simple, accurate method of checking nickel thickness. To meet this, the B.N.F. plating gauge has been much improved in simplicity of operation, stability and accuracy. The utility of the gauge is now being demonstrated to platers so that the industry will have a more satisfactory method of ensuring adherence to the new British Standard for nickel/chromium plating.

Attention is also being given to a comparison of various accelerated corrosion tests and correlation with the results of outdoor exposure, since although the sulphur dioxide test, elaborated in the laboratories in recent years, is now widely accepted in this country, in America more credence is given to the Corrodkote test and the copper-acetic acid-salt spray test, and a valid comparison between all these accelerated tests would be useful in discussion with overseas buyers of electroplated articles.

Another research in the section is a fundamental study of the rôle of organic addition agents to plating solutions in which radio-active tracer techniques are being used to advantage.

Cable Sheathing

During 1959, the Association was granted a patent for a new range of compositions for lead cable sheathing alloys based on the lead-antimony-arsenic system. The alloys combine good extrudability with good structural stability, high ductility under conditions of slow creep, and satisfactory fatigue performance. Field trials of a telephone cable sheathed with one of the alloys have already commenced, and it is anticipated that tests with power cables will be started soon.

Sintering Under Glass

By D. Yarnton, B.Sc., F.I.M. * and M. Argyle†

Department of Metallurgy and Chemistry, Rotherham College of Technology.

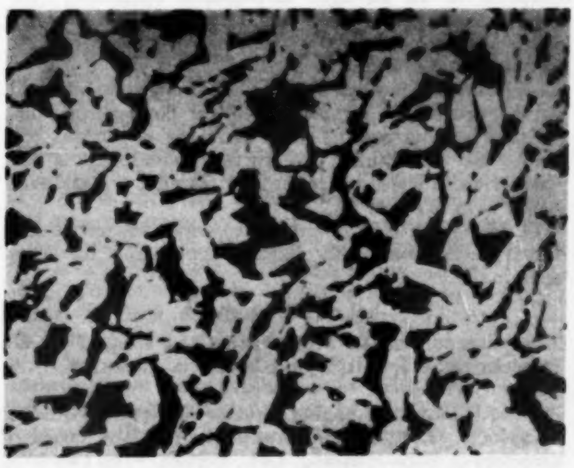
Sintering under glass is suggested as an alternative to vacuum sintering that would have some advantages over the latter. The nature of the product depends mainly on whether or not infiltration by the glass occurs. The possibility of producing a series of new glass-metal alloys by this technique is considered briefly.

THE necessity to avoid oxidation in the sintering of certain powder metallurgy compacts makes stringent control of the sintering atmosphere essential. This control is mainly directed towards the exclusion of oxidising gases such as oxygen and water vapour, and is achieved by sintering under reducing gases which have been dried to low dew points. In spite of such precautions an imperfect result may be obtained in the case of compacts containing highly reactive elements, due to their ready oxidation even in low dew point atmospheres. In such cases vacuum sintering is employed, but this process has certain economic disadvantages owing to the cost and highly technical nature of the apparatus required, and imposes limitations on both the output and size of compact that can be sintered. An alternative process described here may, therefore, be of interest to powder metallurgists.

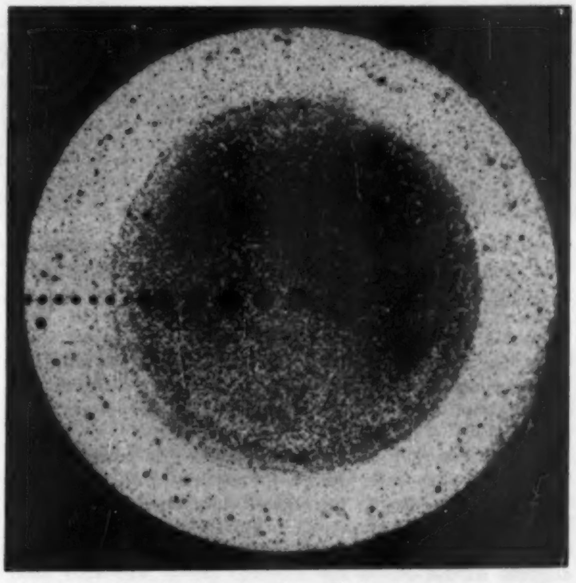
In the Department of Metallurgy and Chemistry at Rotherham College of Technology, it was necessary to introduce sintering *in vacuo* to students taking the course in powder metallurgy. Restrictions on time, however, made full investigations impossible, and it was considered that sintering under molten glass would closely simulate vacuum sintering, since it should result in effective sealing off from the surrounding atmosphere of the compact being sintered.

* Senior Lecturer.

† Assistant Lecturer.



Photomicrograph of section through iron powder compact sintered under glass. Note the partial rounding of the iron particles. ×350



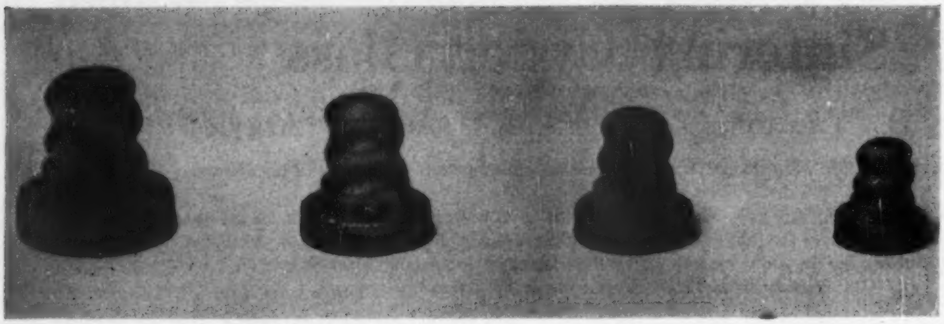
Photomicrograph of section through iron powder compact sintered under glass. The diamond pyramid hardness values for edge to centre were 184, 191, 195, 215, 181, 181, 191, 47·9, 24·7, 20·1, 24·3, 22·2, 20·6. ×6

Two main types of material were treated: (*a*) Alcomax magnet material, representing those products containing reactive elements such as aluminium which normally require sintering *in vacuo*; and (*b*) iron powder products, representing material normally sintered under dry hydrogen.

Experimental

The procedure adopted was to melt glass to a viscous state in a crucible heated in a gas-fired muffle furnace. When the glass was molten and at the requisite temperature, the compacts to be sintered were placed, without preheating, on the surface of the melt, and were subsequently submerged by sinking under their own weight. After sintering for times varying from a half to one hour, the crucibles were removed from the furnace and cooled in air. The compacts were subsequently retrieved by carefully cracking the glass.

The compacts so sintered were then sectioned for microscopic examination, and preliminary results showed that two basic types of structure may result from sintering under glass, depending on whether or not the materials are subject to infiltration by the glass medium. Micro-



A B C D

Compaction in rubber moulds.

A is an ordinary bottle stopper used as a pattern for making a rubber mould. Using the rubber mould and rubber punches in an outer steel sheath, a 95% iron powder—5% stearic acid mix was pressed at 3 tons/sq. in. and then sintered under glass to produce B, the final iron-glass alloy having a Brinell hardness of 121. Despite the large volume of stearic acid needing rapid volatilisation, it will be noted that the compact has not shattered. The dimensional change is comparatively small in view of the fact that it is made up of the contraction of the rubber mould under pressure and the shrinkage on sintering. According to the type of mix used and the pressure applied, the as-pressed dimensions of compacts from a rubber mould can vary appreciably. C is an as-pressed copper powder compact containing 3% camphor and D is a nickel powder compact bonded with 3% camphor and sintered in hydrogen. Note the considerable shrinkage involved.

scopic examination showed that the magnet material was not oxidised, in spite of its containing highly reactive elements and being heated in air during submersion. The sintered density was similar to that achieved by sintering in vacuum and the pores were spherical to cuspoid in shape. Complete solid solution of the components had occurred, giving a well-developed grain structure, and the surface and core were both bright.

In the case of the iron compacts the results were somewhat different. The as-pressed iron compact had oxidised to a degree during submersion, but sintering under glass had completely removed the surface oxide, resulting in a final brilliant, silvery finish. Similarly, any surface oxidation of the internal pores had also been removed, and wetting and infiltration of the pores by the glass had occurred. This had proceeded only a certain distance from the surface, resulting in a case-hardened alloy. The outer case consisted of glass-iron and was free from porosity, whilst the inner core of the original porous iron had apparently not densified during sintering.

In addition to being considerably harder than the core, the outer case also had a much higher corrosion resistance on immersion in water. The glass content of the alloy could easily be varied by varying the pressure of compaction, so that a series of glass-iron alloys of varying composition was readily obtainable. Alloys containing 40% by volume of glass could be hot-forged or rolled, giving excellent glass-metal bonding properties.

Conclusions

The bright sintering of powder metallurgy compacts can be achieved without the use of vacuum or a controlled atmosphere by sintering under glass. The process has both advantages and disadvantages. The size of compact is restricted only by pressing capacity, and those materials normally requiring sintering *in vacuo* can be sintered under glass where the temperature is less than the decomposition temperature. The results obtained may vary according to the nature of the compact and its constituent metals. Thus, if the pore capillaries are sufficiently fine, or the material is not wetted by the glass, infiltration may not occur, in which case, provided there is no reaction between the compact and the glass melt, the product should have properties similar to those of normally sintered material. On the other hand, if the capillaries are coarse and wetting results, infiltration will lead to the development of a metal-glass alloy of peculiar properties. In the case of iron compacts, glass contents as high as 50% by volume do not cause shattering under impact, even though the material is cold short, although it may not be hot short. Considerable increases in hardness and tensile strength result—as compared with a corresponding iron powder compact—as well as increased corrosion resistance. Further investigations may lead to the development of a new series of metal-glass alloys with interesting properties.

The disadvantages are inherent in the process. In using the method on an industrial scale, oxidation might be experienced and removal of the compact from the melt might, perhaps, be troublesome. This difficulty might be overcome by a preliminary canning of the compacts in an air-tight dispensable container. On removal from the bath, the can and adhering glass would be stripped, exposing the contents. Alternatively, a glass-coated can might be used.

Infiltration to form metal-glass alloys might be achieved by the procedure normally used for copper-iron, but whether wetting results under reducing conditions has yet to be ascertained. A further possibility is the production of sheet by running it through a glass bath in the form of strip.

Further work is in progress on various aspects of this development, for which patent application has been made.

Acknowledgement

The authors wish to acknowledge the support of the Department of Scientific and Industrial Research.

Mr. A. W. Lee, managing director of Norton Grinding Wheel Co., Ltd., has been appointed to the board of directors of Behr-Manning, Ltd., Belfast. The two companies are associated ; Norton Grinding Wheel Co., Ltd., being responsible for the marketing of all Behr-Manning coated abrasives throughout the U.K.

Automatic Rolling of Copper Rod

B.I.C.C.'s New Mill Opened by the President of the Board of Trade

The Rt. Hon. Reginald Maudling, M.P., President of the Board of Trade, starting up the new B.I.C.C. automatic copper rod mill at Prescot: on the right of the picture is Mr. W. H. McFadzean, Chairman and Managing Director of British Insulated Callender's Cables, Ltd.

WHEN, on Tuesday, 10th May, 1960, The Rt. Hon. Reginald Maudling, President of the Board of Trade, pressed a button in the roughing mill control pulpit at the Prescot works of British Insulated Callender's Cables, Ltd., he officially inaugurated what is believed to be the largest and most modern copper rod rolling mill in the world. Fully automatic in operation, it is capable of rolling 100,000 tons of copper a year on the basis of two daily shifts of 8½ hours each, and will supply 75% of the rod used by the cablemaking industry in Britain.

Expanding Industry

The electrical engineering industry is expanding rapidly, and is becoming an industry dominated by a few big units, which are themselves progressively getting bigger. So for an organisation like the B.I.C.C. group, which operates the largest cablemaking business in the world, capital investment is necessary just to stay put; to pull ahead requires even more effort of this type. To enable the group to be in a position to meet competition, both at home and abroad, some £30 million has been devoted to new capital outlays in the last ten years, at least half going on expansion and modernisation as distinct from normal replacement.

Towards the mid-fifties, the company embarked upon the substantial task of concentrating all its power cable production in the largely rebuilt and extended factory at Erith, in Kent. The construction of the new No. 4 rod rolling mill at Prescot followed logically and, as it happened, necessarily upon the decision to concentrate power cable production at Erith. Necessarily, because actual construction of the new mill could not start until the site had been cleared by the transfer of Prescot's power cable work to Kent. Logically, because once the cablemaking end of the group's integrated operations had been brought up to a state of maximum efficiency and fully modernised, it was natural to contentrate attention upon the intermediate stage of making the copper rod.

The need for a new mill, which had been recognised for a number of years, arose as a result of the steadily increasing world demand for copper rod and the consequent necessity for additional rolling capacity to meet the group's expanding order book. At the present time, about half the copper rod made at Prescot is used in the group's factories in this country, some 40% is sold to other British cablemakers, and about 10% is exported to B.I.C.C. and other plants abroad, New Zealand, Pakistan and Venezuela being among the principal markets.

The first rod mill at Prescot (No. 1) was installed in 1900, and was followed by the construction of a second in 1915; a third mill had to be set up ten years later. All have been successively modernised and speeded-up, but a point was reached when No. 3 mill became obsolescent and there was insufficient space to modernise it further. With the completion of the new No. 4 mill, which supersedes No. 3 mill, a serious situation has been turned to advantage: No. 1 mill is still rolling heavyweight bars (400–500 lb.) for railway electrification contracts (etc.); No. 2 mill has been turned over to the rolling of aluminium rod; and a heavy burden has been lifted from No. 3 mill, with its limited maximum capacity of 15 tons of coiled copper rod per hour.

Advantages of the New Mill

Quite apart from increased output, the new mill has a number of valuable features. The growth of the electronics industry since the war, as well as other developments, has enormously increased the demand for wire with a high standard of surface finish. The new Ndola refinery in Rhodesia supplies copper wire bars of excellent quality, and the rod rolled in No. 4 mill will have a much better surface finish than the best obtainable in No. 3 mill.

The new mill also has the very considerable attraction of offering much greater flexibility in operation. It can roll rod of any size in $\frac{1}{16}$ in. steps between $\frac{1}{4}$ in. and $\frac{5}{16}$ in., and with its two finishing lines it can produce rods of two different diameters at the same time.

No. 4 mill will also be able to produce rod appreciably more cheaply than No. 3 mill, even though it has cost as much as £1,500,000 to install. Cheapness of production is of crucial importance. The prices of wirebars and of black hot rolled copper rod (of $\frac{1}{4}$ in. and $\frac{11}{16}$ in. sizes) differ on the London Metal Exchange by only £15 odd a ton. This does not seem to be much when set against the cost of the wirebars themselves, currently about £260 a ton, but this margin has to cover, not only the cost of operating the rod mill itself but also freight charges for transporting the wirebars from the port at one end and the coiled rod out again at the other. The low operating costs of the new mill more than off-set its higher capital charges.

The break-even point of the two modern units that make up No. 4 mill sets, as it were, the minimum size capacity of the new mill. The immediate maximum was set by the total amount of copper rod that the B.I.C.C. group could expect to need itself and could reckon on selling to its customers in this country and abroad. With the growth in demand for electrical products generally, and the even more rapidly increasing needs of the group, particularly for the new businesses it has acquired in the last few years, the potential output of Nos. 1 and 3 mills had long been outdistanced, and B.I.C.C. as a group had lately become a substantial " net importer " of copper rod, even after allowing for the supplies of rod made by Thomas Bolton & Sons, Ltd., a B.I.C.C. subsidiary. This year the group reckons on being able to use or sell about 90,000 tons of copper rod, and perhaps in two years' time this will have risen to 100,000 tons a year. When No. 4 mill runs into full operation, all of these requirements will be largely met from this modern, efficient, high quality mill.

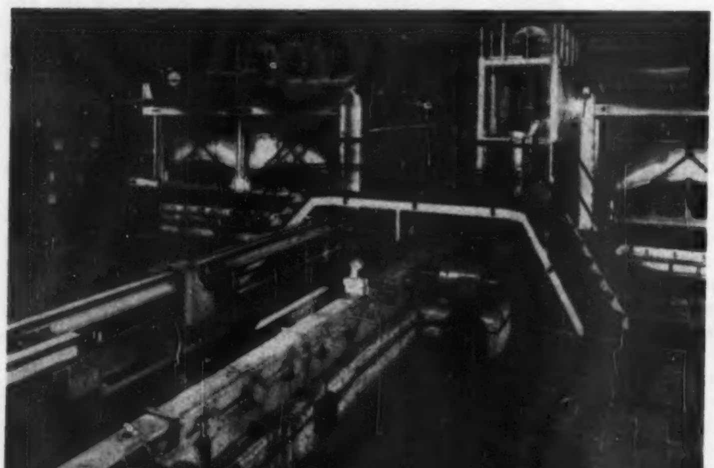
Heating and Roughing

The fact that the mill is capable of converting wirebar into rod at the rate of 400 tons per two-shift day means that large stocks of raw material are required. The copper used in the new mill comes solely from Rhodesia, flowing regularly through the port of Liverpool. At any one time there is some 40,000 tons in the pipeline between Rhodesia and Prescot, and the stockyard at Prescot normally holds 10,000 tons of wirebars valued at more than £2½ million at today's prices.

The capacious open-air stockyard is 400 ft. long × 100 ft. wide, and is served by two 6-ton cranes, which load the wirebars—each 54 in. long and with a tapered cross-section ($4\frac{3}{8}$ in. at the top and 4 in. at the bottom) to facilitate extraction from the casting mould, and each weighing roughly 265 lb.—in 43 ton lots on charge cars drawn by Ruston diesel locomotive to the mill charging area. There are two rail tracks in the charging area, one adjacent to a shallow pit and one adjacent to the four furnace charging conveyors. Each day the pit is filled with bars for night shift use, thus avoiding night work in the yard. The charge cars are unloaded by two Herbert Morris 1 ton overhead travelling cranes (one for each of the two furnaces), which lift the wirebars in rows of seven and transfer them as required to one or other of the four furnace-charging conveyors.

An important feature of the new mill is that it is designed with two separate intermediate finishing and finishing trains. Rods of the same diameter or of two different sizes can therefore be rolled at the same time. The operation of the semi-continuous duplicated trains will be described later, and it will be seen that there are seven wirebars moving simultaneously in the mill, approximately 13 seconds out of phase on each side. An idea of the speed at which the rods are rolled may be gathered by the fact that a $\frac{1}{4}$ in. rod starting on its journey as a wirebar at 584 ft./min. emerges 95 seconds later as a coil some 1,200 ft. long at a rate of 3,500 ft./min.

Such a capacity demanded the use of two furnaces, these being of the walking beam type manufactured by Wellman Smith Owen Engineering Corporation, Ltd. The principle of the walking beam may be briefly described as the use of two interposed parallel sets of girders, one set acting as a static platform, and the other rotating in the vertical plane to impart a forward movement. The latter, in its upward stroke, raises the previously spaced wirebars off the platform, traverses 7½ in. in the direction of the furnace, deposits them in its downward stroke back on to the platform, and returns to its original position ready to begin another timed cycle.



View of the discharge end of the twin reheating furnaces with the approach conveyor to the roughing mill in the foreground. Note wirebar in " sights " of photo-electric cell.

There are two of these walking beams in each furnace, being electrically controlled to operate consecutively and numbered 1 to 4 from left to right. Delivery of wirebars to the walking beams is effected by conveyors, limit switches being employed to space the bars 3½ in. apart. In the course of a complete cycle of the walking beam, one bar is loaded automatically and one dropped off on to the furnace discharge rollers.

The furnaces, situated 30 ft. apart in parallel, are fired with heavy fuel oil through Schieldrop self-proportioning burners (10 to each furnace) located at the top of each combustion chamber. After being heated to 810-820° C. in about an hour, the wirebars are discharged at 13-second intervals on rollers from the bottom end of alternate furnaces to a cruciform turntable between the furnaces.

This turntable rotates backwards and forwards through 90° and its function is to receive and direct the wirebars for entry into the mill train. An operator pushes a button to begin operations and the first wirebar is discharged on rollers from a furnace; the turntable is rotated and the bar is pushed by an electro-pneumatic ram into a single roller-driven guide trough to the first stand—the three-high (five-pass) 20 in. roughing mill, entry to which is controlled by photo-electric means, according to the presence or absence of a hot bar.

The wirebar enters the roughing mill (top centre) from the left, and after five passes it is transferred to the intermediate roughing mill, whose two stands and inter-stand repeater are to be seen in the foreground.

As has already been stated, the new mill incorporates duplicated trains, and it consists of twenty-nine stands of rolls disposed to impart twenty passes when rolling ¼ in. diameter rod. There are in effect two parallel systems so that, viewing the mill from the turntable, one sees in semi-plan form the single train leading to the roughing mill and thereafter two separate trains of stands to half left and half right, the right being shorter because the layout is staggered.

On entering the roughing mill (12 seconds after reaching the turntable) the bar is fed by an electro-pneumatic pusher through the first pass (12·427 sq. in.), raised on manipulating gear and pushed back again through two further passes (8·90 sq. in. and 5·63 sq. in.), manipulated up and sideways once more before being pushed through two subsequent passes (3·945 sq. in. and 2·50 sq. in.) and into position on a chain-driven side transfer table.

The rod emerges from the roughing mill 30 ft. long, the time taken so far being 30·45 seconds. After being transferred sideways and deposited in the intermediate roughing train, the rod is conveyed between a set of pinch rolls, operated by a photo-electric cell, in a backward direction towards the 15 in. two-high two-stand intermediate roughing mill.

Pass 6 (the first stand of the intermediate roughing mill) marks the beginning of the duplicate trains. Rods enter these trains alternately by means of an automatic switching device, loop in an anti-clockwise direction through 180° on a semi-circular tray (looping being necessary to accommodate the rapid increase in rod length), and emerge with a length of 64·7 ft. through a second stand of rolls, 44·65 seconds after positioning on the turntable.

Finishing

The rods now pass directly to the 11 in. cross-country intermediate finishing mills which are of zig-zag formation and comprise six looping stands each. In these stands the rods increase in length to 429 ft. in a matter of 8·20 seconds, the total time being 67·45 seconds. All the roll housings, except those in the finishing mill, are pre-stressed. This is the only non-ferrous rolling mill in the British Isles to have this feature, which gives a neat and compact appearance to the whole layout. All the rolls are of forged steel, their composition varying with duty.

Next the rods go into the 9 in. 7-stand continuous finishing mill, and it is of interest to note again that No. 4 rod mill is the only one of its kind in the country to have two separate intermediate finishing and finishing mills, being so designed to enable two sizes of rod to be rolled at the same time. Rods enter the finishing mill at a speed of approximately 30 ft./sec., and in the 2 seconds it takes to reach the coiler they are accelerated to a speed roughly double this figure.

Cantilever suspended multi-grooved forged nickel-chromium-molybdenum steel ring rolls are used and the stands, which are alternately horizontal and vertical to avoid twisting the section at high speed by the use of twist guides, are speed-controlled automatically. Cantilever suspension of the 9 in. rolls is a feature of the new mill, being unique in this country in any type of mill, ferrous or non-ferrous. Variation in roll centres is obtained by having one roller bearing mounted in an eccentric sleeve rotated by hand-operated worm gear. To roll a ¼ in. rod, all the seven passes of the finishing mill (that is, twenty passes in the complete rolling process) are employed; but it is possible to by-

View of one of the finishing lines. On the right is the 6-stand intermediate finishing mill and on the left the 7-stand finishing mill. The gallery on the left provides a view of the whole plant: the second finishing line lies on the other side of the elevated control pulpit on the right of this picture.

pass the last stages of the finishing mill, as required, to give six rod sizes with the minimum of roll changing.

There are two pouring type coilers at the end of each finishing mill, situated one on each side of a quenching tank, the rod being directed to the appropriate coiler by selector switch. The coil is pushed from the coiler to a lift platform, lowered into the quench tank and raised again to bench level. Dogs on a conveyor remove the coils of rod from the quenching tank towards a mechanical fork lift at the end of the conveyor which then loads the coils on to a capstan. Each boom of the capstan will hold nine coils, and when it is fully loaded the capstan is rotated through 90° and unloaded by a stacker truck—a fork lift truck with the forks removed and a single forward-facing boom fitted. The coils are finally taken to a large storage area at the end of the shop which is served by a 5-ton overhead travelling crane.

Inspection

The rods are under constant quality control which uses three main methods of test. First, the temperature of the wirebars is recorded at the cruciform turntable; secondly, a micrometer check on coils leaving the conveyor is made every five minutes to prove sectional area; and thirdly, a reverse torsion test is made on test bars cut from the coils. Ten turns are made in the sample to determine the degree of oxide scale present. By taking off the turns again, rolling defects are detected.

Lubrication and Cooling

Flood lubrication with a 3½% solution of Shell M.3 soluble rolling oil in water is used for all the roll grooves, roller guides, stripper gear and channels. This system consists of two settling tanks of 3,000 cu. ft. each, and one sump giving a total capacity of 60,000 gal. in continual circulation. Four pumps and one standby, each capable of delivering 600 gal./min., are used to circulate the solution which gravitates back to the settling tanks. To maintain the supply, a 1,000-gallon mixing tank is provided.

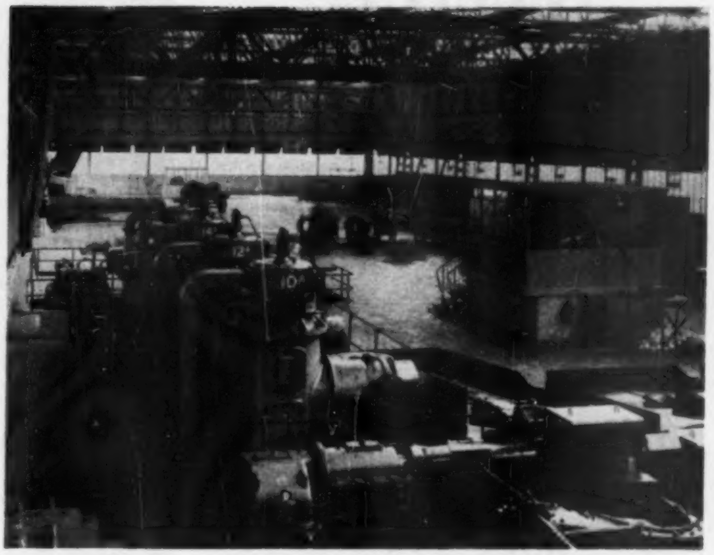
The rolls are carried on S.K.F. spherical-seating roller bearings lubricated with Shell Alvania EP2 grease, and protection of the bearings from contamination by water or scale is achieved by means of grease-filled labyrinth seals. The seal duty is very arduous, and they are regreased once per shift. All small motors have bearings packed with Alvania Grease 3, developed for long life in rolling bearings. There are some 3,000 grease and oil nipples in the plant requiring constant planned attention. Apart from the soluble oil, the largest lubrication system is that for the main pinion and gear, which comprises 3,000 gallons of Shell Macoma Oil 68—a heavy duty gear oil containing a special load-carrying additive which protects the gears from the high shock loads experienced in plant of this sort. The arrangement is such that, from a control panel outside the main mill building, in the electrical section, the whole system can be continuously checked by telltale lights on a diagram panel and recorders. Stand-by pumps are automatically switched on if required, and failures are indicated by light signals and klaxons. To ease fault finding, the main lubrication control panel has a set of small windows, each with the name of a particular section on it: failure in any part of the mill causes the appropriate window to be illuminated.

There are two main cooling problems. First, the quench water, which is in a closed circuit system with four pumps, two working and two standby. The water circulates at 15,400 gal./hr. and is cooled from 146 to

Rod coiler, coil quenching unit and discharge conveyor.

96° F. by a forced-draught cooler in the circuit. The copper drops about 220° C. in the 82 seconds during which, to produce ¼ in. diameter rod, it passes through the mill rolls.

The second problem is forced air cooling for the electrical department and the main motors. The electrical section is housed in an extension building 200 ft. by 30 ft., two storeys high and with a low baement, in which there are 32 miles of B.I.C.C. cable. Three fans draw air from outside the building and force it through a labyrinth filter which is periodically flooded with oil. The air is forced into the basement and up into the first floor area. Some of the air flow is boosted by further fans and ducted to the main motors on the mill floor. The maximum air flow requirement for ventilation is 55,000 cu. ft./min.



One of the two continuous finishing mills: the last stand of the intermediate finishing mill can be seen bottom right.

Electrical Equipment

The English Electric motors used in the plant total 6,000 h.p. and the maximum power requirement is 2½ MVA. The roughing and intermediate roughing mills are driven by 6·2 kV., 600 h.p. slip-ring induction motors. The two intermediate finishing mills are split, each set of three stands being driven by a 500 V., 500 h.p. motor—D.C. with variable speed control. Each stand of the two finishing mills is fitted with a 500 V., 100 h.p. D.C. variable speed motor. These D.C. motors are fed from a pair of 1,250 kV. grid controlled mercury-arc rectifiers. The four rod coilers also have variable speed D.C. motors of 65 h.p. rating, but these are fed from a pair of motor-generator sets so that each motor has fully independent control to allow for coiling rod of different diameters.

The main control pulpit near to the roughing mill is the centre of operational control. Two other pulpits are arranged near to the finishing mills and in these provision is made for controlling the speed of each of the mills to ensure balance over the whole unit. An automatic system is incorporated in the electrical motor control to correct the mill speed under starting load when a fresh rod enters the rolls. By this device the speed of roll action is maintained very nearly constant under varying load. The three pulpits and the electrical control room are linked by microphones and loudspeakers, so that there is immediate and constant contact between all members of the operating staff.

General view of the main electrical control room.

Automation is a feature of this mill, which is operated by a labour force of seventeen men per shift. Fourteen photo-electric cells situated at key points watch the progress of the rods and control their timing and spacing. This helps to ensure continuous high speed operation, and guards against the danger of overlapping, since there are seven wirebars moving simultaneously through the mill at any given time.

All the pushing and pulling mechanisms in the mill are operated electro-pneumatically. Air for this purpose is obtained from a ring main supplied by two compressors and one standby, each capable of delivering 300 cu. ft./min. of free air at 80 lb./sq. in. One 200 cu. ft. receiver is situated in the line.

British Made

On the engineering side, the new mill is believed to be the most up-to-date copper rod mill in the world, incorporating in one plant all the latest techniques that can be found seriatim in the new copper rod rolling mills on the continent, and some additional ones as well. It is entirely British designed and built, being a joint operation by B.I.C.C. and the Brightside Foundry and Engineering Co., Ltd., of Sheffield. The drives are by the English Electric Co., Ltd., and much of the construction work for the building was carried out by Sir Alfred McAlpine & Son, Ltd.

In the Birthday Honours List

The names of those honoured by H.M. The Queen in the Birthday Honours List included the following.

KNIGHTHOOD

W. H. McFadzean, President, Federation of British Industries.

B. F. J. Schonland, C.B.E., Director, Research Group, United Kingdom Atomic Energy Authority.

G. B. B. McIvor Sutherland, Director, National Physical Laboratory.

H. G. Thornton, Foreign Secretary, The Royal Society.

C.B.

J. S. McPetrie, Director-General of Electronics Research and Development, Ministry of Aviation.

K.B.E.

R. Cockburn, C.B., O.B.E., Chief Scientist, Ministry of Aviation.

C.B.E

T. E. Allibone, Director, Research Laboratory, Associated Electrical Industries, Ltd., Aldermaston.

G. W. A. Birkett, Superintendent of Production Pool, Admiralty.

E. T. C. Grint, Chief Labour Officer, Imperial Chemical Industries, Ltd.

E. J. Hunter, J.P., Chairman, Swan, Hunter and Wigham Richardson, Ltd.

W. G. Mitchell, Director, Mitchell Bros., Sons and Co., Ltd.

R. A. Smith, Chief Scientific Officer, Royal Radar Establishment, Ministry of Aviation.

F. R. Tubbs, Director, East Malling Research Station.

O.B.E.

W. R. Andrew, Chief Constructor, Ship Department, Admiralty.

F. W. Bates, Works Director, Kelvin and Hughes, Ltd.

G. M. Boyd, Head, Technical Records Department, Lloyd's Register of Shipping.

L. F. Broadway, Head of Research Laboratories, Electrical and Musical Industries, Ltd.

R. J. Clayton, Manager, Applied Electronic Laboratories, General Electric Co., Ltd.

S. Gunson, Superintendent, Mechanical Engineering, Atomic Weapons Research Establishment, Aldermaston, United Kingdom Atomic Energy Authority.

G. M. Harvey, Managing Director, British Oxygen Wimpey, Ltd.

D. McKenzie, Principal Scientific Officer, Armament Research and Development Establishment, War Office.

A. E. Mason, lately Managing Director, BP Refinery (Kwinana), and Director, BP Australian, Ltd.

H. W. O'Connell, Principal Examiner, Patent Office, Board of Trade.

L. Patrick, Head, Government Contracts Department, Imperial Chemical Industries, Ltd.

R. G. Prenter, Director, MacTaggart, Scott and Company, Ltd.

H. G. R. Robinson, Principal Scientific Officer, Ministry of Aviation.

F. H. Saniter, Director of Research, The United Steel Companies, Ltd.

A. A. Smales, Deputy Chief Scientist, Atomic Energy Research Establishment.

F. B. Thole, lately Senior Principal Scientific Officer, Ministry of Power.

E. F. Thompson, Director and General Manager, British Small Arms Guns, Ltd.

M.B.E.

T. J. Bennett, Technical Class, Grade 1, Royal Mint.

C. Boorman, Research Manager, Capenhurst Works, Development and Engineering Group. United Kingdom Atomic Energy Authority.

J. H. T. Borland, Chief Designer, Glenfield and Kennedy, Ltd.

R. L. Burrows, B.E.M., Foreman, Engineering Branch (Technical, Grade 1), Admiralty Gunnery Equipment Depot, Glasgow.

G. A. Cain, Assistant Manager, C. and H. Crichton, Ltd.

D. Cemm, Engineer II, Aeronautical Inspection Directorate, Ministry of Aviation.

D. N. J. Cole, Chief Engineer Draughtsman, Vosper, Ltd.

W. J. Crooks, Production Manager, Aberdare Cables, Ltd.

H. Denman, Technical Representative, Moorwoods, Ltd.

R. P. Farley, Engineer II, Inspectorate of Armaments, Ministry of Aviation.

S. J. Forsyth, Export Manager, Ford Motor Co., Ltd.

L. Godber, Local Director and General Manager, Newton Chambers and Co., Ltd.

W. R. Groves, Superintendent, Short Brothers and Harland, Ltd.

J. Harper, Chief Liaison Officer, Admiralty Contracts, Heenan and Froude, Ltd.

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T. V. Keelan, Assistant Education Officer, Plastics Division, Imperial Chemical Industries, Ltd.

K. G. Lloyd, Chief Export Estimator, John Thompson Water Tube Boilers, Ltd.

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T. P. McDermott, Engineer II, Royal Ordnance Factory, Woolwich.

G. F. Midwood, lately Engineer II, Royal Aircraft Establishment, Ministry of Aviation.

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R. G. Protheroe, Manager, Purfleet Terminal, Esso Petroleum Co., Ltd.

H. Radford, Dock Master, Cammell Laird and Co. (Shipbuilders and Engineers), Ltd.

R. W. H. Robinson, Process Superintendent, Folland Aircraft, Ltd.

A. E. Rolton, Engineer III, Royal Ordnance Factory, Radway Green.

M. G. Smith, Divisional Manager, Mechanical Automation Division, Elliott Brothers (London), Ltd.

S. Thompson, Senior Assistant Engineer, Appleby Frodingham Steel Company, Branch of the United Steel Companies, Ltd.

Mrs. F. Vousden, lately Clerical Officer, Warren Spring Laboratory, Department of Scientific and Industrial Research.

C. V. Waddell, Electrical Engineer, Cowans Sheldon and Co., Ltd.

G. H. Whittaker, formerly Engineering Technical Class, Grade I, Royal Aircraft Establishment, Ministry of Aviation.

J. R. Wight, Electrical Manager, Scotts' Shipbuilding and Engineering Co., Ltd.

B.E.M.

F. C. Ackerman, Foreman Propeller Patternmaker, J. Stone and Co. (Charlton), Ltd.

J. G. Anderson, Assistant Foreman Electrician, Vickers Armstrongs (Shipbuilders), Ltd.

C. G. Andrews, Senior Assistant (Scientific), National Chemical Laboratory, Department of Scientific and Industrial Research.

A. C. V. Baker, Foreman of Model Shop, E.M.I. Electronics, Ltd.

G. Baker, Foreman Corebuilder, Associated Electrical Industries (Rugby) Ltd.

Mrs. L. M. Cornwall, Senior Chargehand, Electronics Group, Plessey Company, Ltd.

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F. Duggan, Glazier, The Mond Nickel Co., Ltd., Swansea.

Miss E. M. R. Fisher, Senior Scientific Assistant, Atomic Energy Research Establishment.

G. H. Johnson, Shearsman, The Steel Company of Wales, Ltd.

J. McDonald, Foreman Boilermaker, Drypool Engineering and Dry Dock Co., Ltd.

C. L. Oakes, Assistant Technical Officer (Engineer), Imperial Chemical Industries, Ltd., Redcar.

L. R. C. Percival, Foreman (Technical Grade II), Rocket Propulsion Establishment, Ministry of Aviation, Westcott.

L. Richmond, Ironworker, Royal Aircraft Establishment, Ministry of Aviation.

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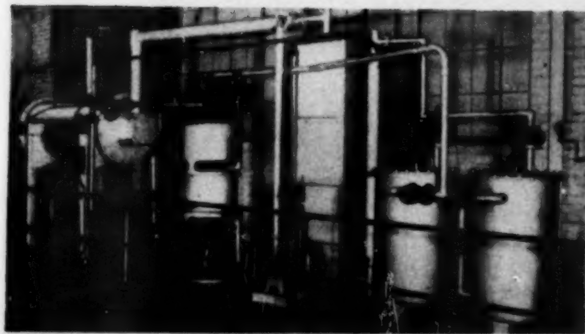

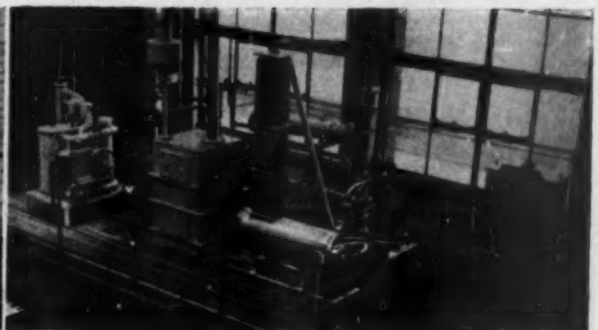

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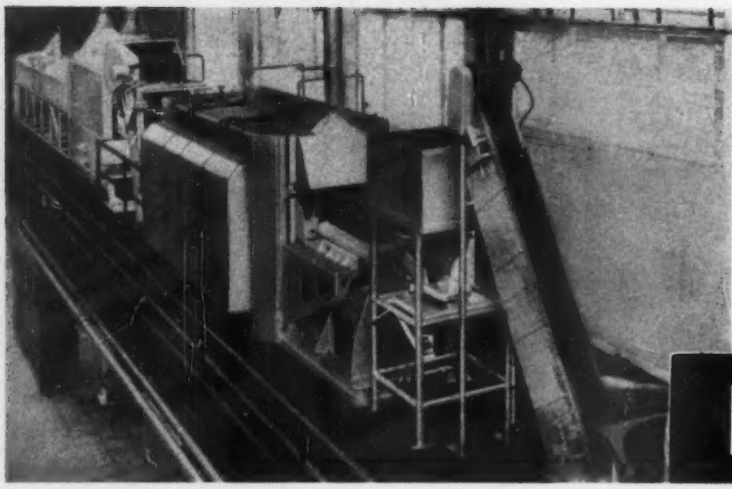

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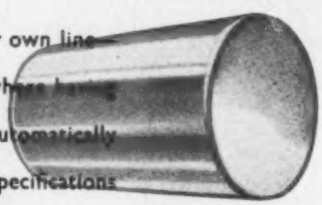

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Recent Heat Treatment Furnace Installations

Annual Survey of Developments

The heat treatment of metals and alloys embraces a series of operations designed to improve their physical properties; a full system of routine checks and controls is necessary to maintain efficiency, as well as an adequately trained staff, but up-to-date furnaces and control equipment are essential. Many variables are involved which affect the quality and overall cost of heat treated products and great care must be taken in estimating requirements and in designing the furnace to meet them. Some guidance in selection of new plant may be obtained from this review which refers briefly to a few of the more recent installations and the purposes for which they are being applied.

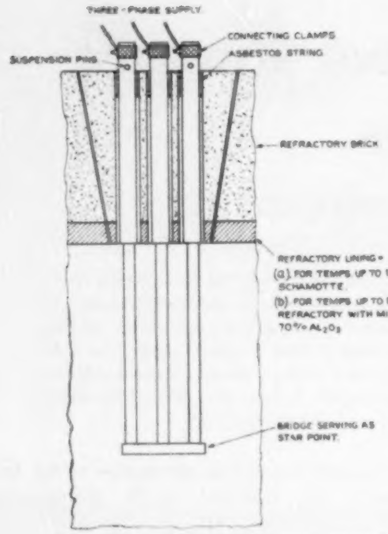
HEAT treatment, as is well known, is a combination of operations involving the heating and cooling of a solid metal part for the purpose of obtaining certain desirable properties, such as increased tensile strength, improved ductility, and resistance to fatigue and shock stresses. Basically, it involves no chemical change in the material treated, the transformations occurring including phase changes, the passage of compounds into or out of solid solution, and the expansion and contraction of solid parts. Thus, except in such processes as the carburising and nitriding of steel, there is no change in the average composition of the material.

The first and final operations in any heat treatment cycle involve heating of the cold metal and its subsequent cooling to atmospheric temperature. The successful operation of any cycle depends upon the rate at which heat may safely be put into or taken from the material. Rates of heating and cooling may vary widely, from very low to very high, such as, for example, when a cold part is dropped into a lead or salt bath, or when hot parts are plunged into a quenching tank. Large parts of soft steel, or small parts of hard steel, can easily be ruptured by heating too rapidly; even if the part does not crack, uneven heating or cooling may distort it. Thus, the heating rate must be adjusted to the size of the material or component, its condition during heating, and the eventual temperature required. It will be realised that charging a cold load into a hot batch furnace will give the material—and the furnace—quite a thermal shock. The cooling rate is not less important, as the required properties of the material may be governed largely by this rate. It must be understood that no particular heat treatment procedure will, in every case, provide the maximum properties; it is generally necessary, therefore, to develop the most desirable combination of properties in the material for a specific purpose.

In addition to the foregoing procedures for improving the properties of metals and alloys, considerable attention is being given to the heating of these materials to facilitate the necessary forming operations. The influence of heat on the final structure, as well as on manipulation, is now more fully appreciated and greater care is being taken in controlling temperatures and in protecting the material. Whether heating or the complete heat treatment process is to be carried out, satisfactory results depend on the design of the furnace, its equipment, the material to be manipulated or treated, and the furnace operator. The primary objective is to produce a high grade product at low cost, using that form of heating medium and type of equipment which will give these results under the conditions prevailing in the works concerned. It should not be overlooked that the output of a furnace, allowing a reasonable margin for overload, is decided at the design stage, and cannot readily be increased beyond this capacity without risk of unsatisfactory treatment.

Although not strictly within the field of this survey passing reference may be made to the fact that The General Electric Co., Ltd., recently received an order from the United Kingdom Atomic Energy Authority, Risley, covering reduction and fluorination furnaces for use in the production of plutonium metal. The fluorination furnace is rated at 10 kW. and is of the horizontal front loading type, complete with muffles, the inner surface of the muffles and doors being lined with platinum. A forced cooling system is incorporated to enable the charge to be cooled within the stipulated time. The furnace for the reduction process is rated at 50 kW. It is of a bell-type design and has a forced cooling system similar to the fluorination furnace. The electrical equipment includes regulating transformers, temperature control fitments and the necessary switchgear.

Of particular interest in the high temperature field is the introduction by Siemens-Schuckert (Great Britain), Ltd., of two new types of electric furnace element, which are intended to complement this firm's existing range of "Silit" high temperature elements. The first of these new elements is the "Silit-Cesiwid" three-phase element (Fig. 1) designed for electric furnaces with a maximum temperature of 1,500° C. The maximum element temperature recommended is 1,550° C., although higher element temperatures are obtainable in certain designs of furnace. It constitutes a balanced-load three-leg element, with a silicon carbide bridge (physically and electrically connecting the three hot zones) forming a star point for the element itself. Apart from the strong and robust construction of the element, improvements in the process of manufacture have led to corresponding improvement in the length of useful life which can be expected from this element. Because of varying factors, such as furnace design, heating cycle, furnace atmos-



Courtesy of Siemens-Schuckert, Ltd.

Fig. 1.—A new three-phase heating element for maximum temperature of 1,500° C.

pheres, element loadings and temperature levels, it is not possible to make a sweeping statement regarding the length of life under all conditions. It is possible, however, to state that an operating life of 7,000 hours is quite feasible. The wattage loading characteristic of this new element is extremely high—wattage loadings of more than 21 W./sq. cm. being easily achieved.

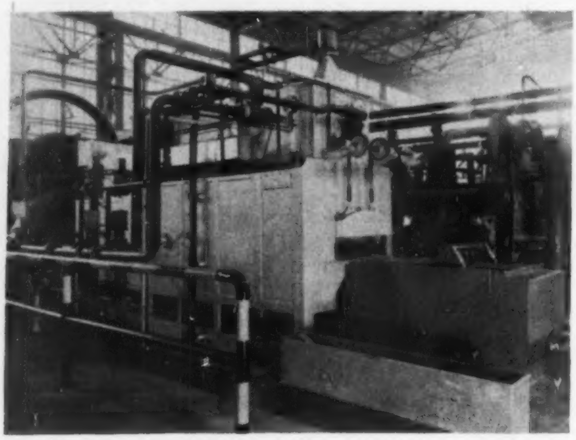
The second new member of the " Silit " range is the " Mosilit " extra-high temperature furnace element, which has a maximum element temperature of 1,700° C. The hot zone of " Mosilit " is composed of molybdenum disilicide, with molybdenum-free lead-ins. Unlike silicon carbide elements, this new element has no electrical " ageing " properties and the normal expectation of useful element life is of the order of 10,000 hours. By virtue of a self-generated silicon dioxide skin, it is impervious to the majority of the reducing and protective atmospheres used in industry. The wattage loading characteristic of " Mosilit " is higher than the other Silit elements, namely, more than 40 W./sq. cm. " Mosilit " is being made available in five standard forms.

The scale-free heating of steel for hot working is becoming increasingly attractive to the steel industry and a new method (covered by patents taken out by Dr. A. G. E. Robiette, held by Metallurgical Oxygen Processes, Ltd., and subsequently improved by Indugas m.b.H., of Essen and patented by them) should do much to satisfy this demand. This scale-free method of heating steel uses air preheated in a simple cross-tube type recuperator without the necessity for oxygen enrichment associated with the earlier operation of this process. Furnaces, one of which will be referred to later in this survey, have been working for some time producing billets entirely free from scale with a gas consumption less than that normally associated with reheating furnaces of the conventional type.

The foregoing indicate some of the trends associated with furnace design, but there is a growing need for greater impact, fatigue, and high temperature strengths from the metals and alloys treated. Many variables are involved, each of which affects the quality and overall cost of the treated products and great care is necessary in estimating requirements and in designing the furnace to meet them. As will be noted from a few of the more recent installations described, furnace designers are continuing to satisfy the demands made upon them.

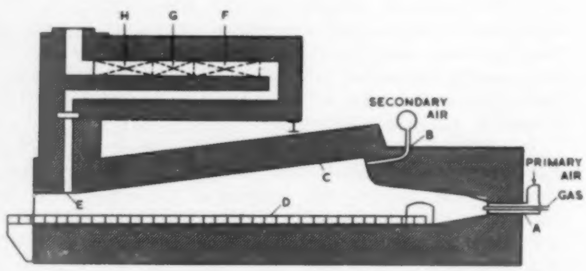
Heating for Working

The scale-free method of heating steel, referred to above, is incorporated in the recently perfected " Pro-tek" furnace by Gibbons Bros., Ltd. This method uses air preheated in a simple cross-tube type recuperator without the necessity for the oxygen enrichment associated with the earlier operation of this process. Furnaces incorporating this design have been working for some time producing billets entirely free from scale. A typical example is that shown in Fig. 2, the design of which is shown diagrammatically in Fig. 3, from which it will be seen that the burners *A* are mounted in the end wall of the discharge end of the furnace. They are supplied with town's gas (preheated to 300° C.) and approximately half the theoretical volume of air for complete combustion (preheated to 650° C.). The products of incomplete combustion from the burners, which are highly reducing to iron, envelop the row of billets coming in the opposite direction from the charge end. In the roof are a number of secondary air inlets *B*



Courtesy of Gibbons Bros., Ltd.

Fig. 2.—The recently perfected " Pro-tek " furnace for heating billets free from scale.



Courtesy of Gibbons Bros., Ltd.

Fig. 3.—A sketch showing the design of the furnace producing scale-free billets.

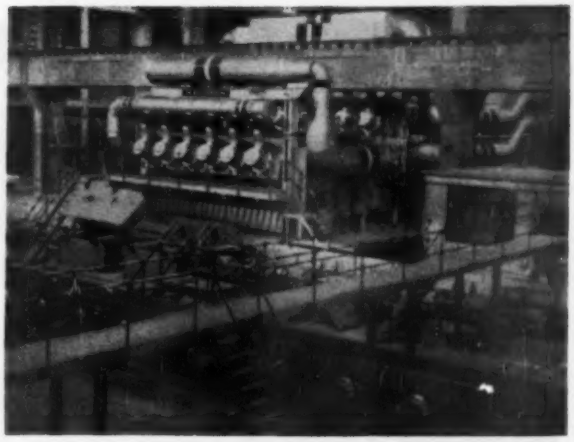
through which the remainder of the air for complete combustion is admitted. By this means the products of incomplete combustion are burnt from the top so that the heat generated is directly or indirectly radiated into the primary combustion zone, largely due to the arrangement of the roof, enabling it to be used directly for the heating of the furnace charge. The products of complete combustion first come into direct contact with the billets near point D in the diagram, preheating them to a temperature of 800°–900° C. At point E the flue gases are withdrawn at 1,100° C., the sensible heat therein being used to preheat the gas and the primary and secondary combustion air in recuperators F, G, and H, being finally discharged at 450°–500° C.

The successful application of this process relies on the above mentioned flow pattern being established, and this depends on a correct furnace profile, together with the correct inlet speeds for the gas and primary and secondary combustion air. When installed this furnace is simple to operate, requiring only occasional technical control, and is entirely automatic in operation over a wide range of billet sizes and outputs.

In addition to the complete open hearth steel melting shop for the new integrated steelworks at Aviles for the Spanish Government, the Wellman Smith Owen Engineering Corporation, Ltd., were also responsible for the design and construction of the furnaces and their ancillary equipment for the rolling mill department. To heat the 6½-ton ingots for the 42 in. blooming mill, the initial installation comprised fourteen Wellman bottom-fired recuperative soaking pits, but these notes refer to the heating equipment for the 3-stand 32 in. section mill. To serve this mill one continuous bloom reheating furnace was provided to reheat cold stock and one bloom wash heating furnace to deal with large hot blooms direct from the 42 in. mill for the production of joists up to 18 in. by 6 in.

The continuous bloom reheating furnace, the discharge end of which is shown in Fig. 4, receives cold blooms 6 in. and 12 in. square by 20 ft. long, each bloom weighing approximately 1·1 and 4·4 tons respectively. The blooms are charged into the furnace through an electrically operated door by means of an electrically operated pusher, carried through the furnace upon water cooled skids and end-discharged through a multiple flap type door on to a roller track feeding the mill. The furnace, which has an effective length of 75 ft. and a width between walls of 22 ft. to suit one row of blooms, has an output of 60 tons of blooms per hour, heated from cold to a rolling temperature of 1,250° C. It is fired by mixed blast furnace and coke oven gas, with a ratio of 85% blast furnace gas to 15% coke oven gas, giving a calorific value of 155 B.Th.U./cu. ft.

Combustion is effected by means of burners, arranged for top heating and underhearth heating, as well as top heating in the soaking zone, which have a total maximum capacity of the order of 900,000 cu. ft./hr. of mixed gas at a pressure of ¼–½ in. W.G. and recuperated air at a temperature of 300° C. and a pressure of approximately 6 in. W.G. Combustion air is preheated by two banks of Newton metallic needle recuperators operating in parallel, the heating elements first in the flow of waste gas being of nickel-chromium alloy to withstand a waste gas temperature of 1,000° C. Water cooling of the furnace, in addition to the skids, incorporates a water cooled lintel spanning the discharge door which, allowing

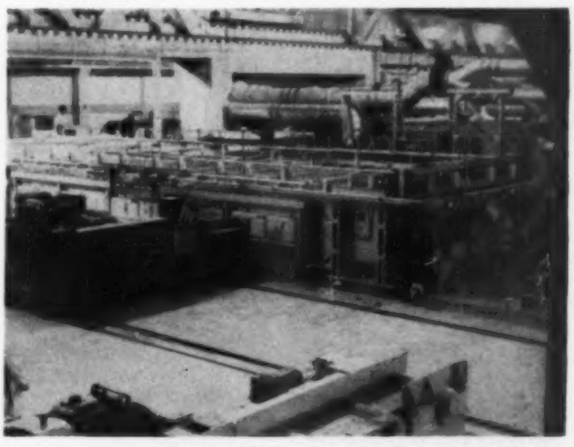


Courtesy of The Wellman Smith Owen Engineering Corporation, Ltd.

Fig. 4.—The continuous bloom reheating furnace for use in the new integrated steelworks at Aviles.

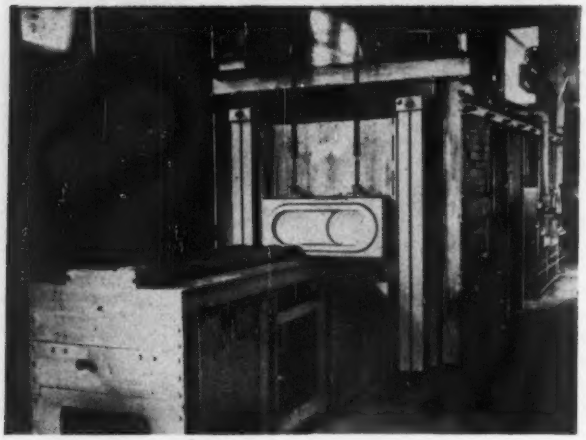
for a temperature rise in the water of 25° F., requires a total of 15,000 gallons of cooling water per hour. Control of the temperature obtaining in the preheating and treating zones and of the air/gas ratio is effected manually, but in the soaking zone temperature and combustion are automatically controlled and recorded. The furnace is also provided with automatic pressure control.

Adjacent to the continuous bloom furnace is the bloom wash heating furnace, shown in Fig. 5, which receives direct from the 42-in. mill blooms at a temperature of approximately 950° C. for heating to 1,250° C. before being passed to the 32-in. section mill for rolling into joists. This furnace has an output of 80 tons/hr. when heating maximum bloom sections, each weighing 4·4 tons ; its hearth measures 51 ft. 6 in. long by 22 ft. clear between front and back walls. In common with wash heating practice the furnace is reversing regenerative, but in this case air only is regenerated. Constructed below each end of the furnace is a pair of regenerator chambers. As with the bloom furnace, mixed gas is



Courtesy of The Wellman Smith Owen Engineering Corporation, Ltd.

Fig. 5.—The bloom wash heating furnace located adjacent to the furnace in Fig. 4.

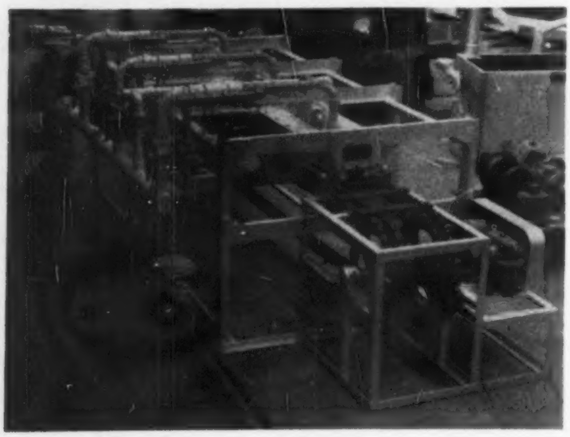


Courtesy of The Incandescent Heat Co., Ltd.

Fig. 6.—A continuous pusher furnace for heating billets for forging.

used, combustion being established in two combustion chambers at each end of the furnace. The furnace pressure is controlled by automatic operation of the furnace main dampers and the temperature in the furnace is continuously recorded by a 6-point recording pyrometer with a 0–1,600° C. range. Reversal signalling equipment is provided incorporating a 2-point, 2-zone recording pyrometer and reversals of fuel, air and waste gases are push button operated. Gas flow is indicated and continuously recorded whilst air flow is only indicated. All instruments are panel mounted and installed in an instrument house.

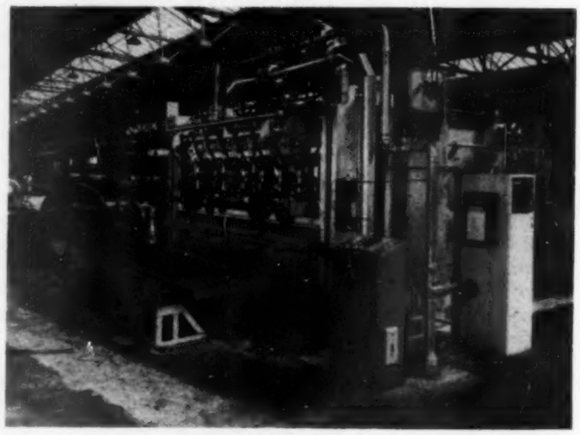
Another example of billet heating is provided by the continuous pusher furnace shown in Fig. 6; it is used for heating billets for forging and is fired by preheated fuel oil having a viscosity of 90–100 sec. Redwood No. 1 at the burner. The furnace is 3 ft. 6 in. wide between the side walls and the heating chamber is 21 ft. 6 in. long. The heating chamber is divided into a preheating zone and a final heating and soaking zone. Two burners in the discharge end wall fire over the final heating and soaking hearth. Transverse firing is arranged in the preheat section, using burners fitted in staggered formation in the side walls. The furnace and pusher are 35 ft. long and 10 ft. 6 in. wide overall, and the installation is designed for an output of 50 cwt./hr.



Courtesy of Dowson and Mason, Ltd.

Fig. 7.—A furnace specially designed for the centre "nibbing" of leaf spring plate.

A specialised type of furnace recently installed at the Crewe Works of the British Transport Commission is that shown in Fig. 7. It is used in connection with the centre "nibbing" of leaf spring plates. Although this process is frequently performed cold, the life of the press tools is much prolonged if the plates are heated. The furnace is designed to heat the centre of the plates only, the heated length being approximately 3 in., the ends remaining comparatively cold. Heating is by multiple jet type burners firing vertically downwards, giving hot gas and flame impingement on the spring plates. The conveyor is motor driven with a variable speed reduction gear. This furnace, which has an overall length of 16 ft. 6½ in. and is 6 ft. 3 in. wide, is designed for an output of a hundred plates an hour, measuring 5 in. wide × ⅜ in. thick and varying from 8 in. to 4 ft. 6 in. in length.



Courtesy of Stein and Atkinson, Ltd.

Fig. 8.—A dual-purpose furnace for the production of large copper tubes.

The production of large copper tubes by extrusion sometimes requires a dual-purpose furnace, firstly to heat the billets for piercing and partial forming, and secondly to heat the partly formed tubes for further expansion before the drawbench. The furnace shown in Fig. 8, installed at Wednesbury Tube Works, is designed for this purpose. In this case the billets or tubes are charged singly (two rows of billets or a single row of tubes) on to a series of alloy steel arms which carry them forward into the furnace. At the end of each forward stroke the stock is deposited on the hearth and the arms are turned through 90° so that they pass under the stock ready for the next forward movement. The arms are again turned through 90° to the original position, whereupon they lift the stock off the hearth and carry it forward another stroke. The stock is finally discharged down a slope to the table taking it to the extrusion press. All motions are operated by oil/hydraulic equipment. The furnace is fired with town's gas with burners at the

discharging end, and is automatically controlled for temperature and fuel/air ratio. It has an output of $2\frac{1}{2}$ tons/hr.

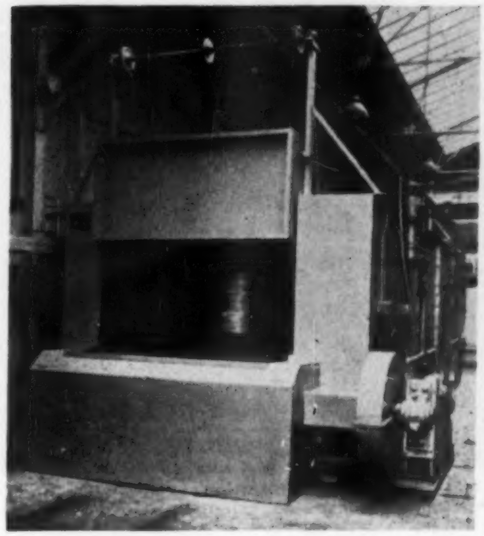
The use of air circulation heating for aluminium and aluminium alloys is increasing in popularity, and the conveyorised gas-fired furnace shown in Fig. 9 incorporates the J.L.S. patented air circulating system, which gives a very high degree of temperature uniformity throughout the working space. This furnace is designed chiefly for preheating aluminium alloy ingots prior to hot working. It has a capacity of 15 tons, which is normally formed of ingots 6 ft. by 4 ft. by 2 ft. As will be noted from the illustration, the furnace is not confined to preheating, but may be used for annealing or any other form of heat treatment required by aluminium and its alloys. The design of this furnace constitutes a major departure from the conventional type of unit constructed of refractory brick. In this case, the inner and outer casings are of steel plate, with steel wool or similar insulation in between. In addition to high thermal insulation, achieved with low thermal storage, the double cased form of wall construction has greatly reduced running costs. Although the furnace illustrated is gas fired, electricity or oil may be used as the heating medium.

A new preheating box furnace, for operation at temperatures up to 1,000° C. is shown in Fig. 10; it has an effective heating zone 10 ft. long × 4 ft. wide × 1 ft. 3 in. high. Included among the specifications around which the furnace was designed were (*a*) the temperature distribution throughout the furnace to be within ±5° C.; (*b*) a 15 minute recovery time without overshoot was required for reheating billets after rolling; and (*c*) the furnace lines were to be in keeping with modern design. In order to give quick recovery time and also close temperature control, the furnace was designed with two zones, each of 75 kW. Each zone is controlled by means of a Honeywell Brown potentiometric type temperature controller and saturable reactor. As will be noted in the illustration, the furnace has been given a streamlined appearance. The nickel-chrome tape elements are housed in sillimanite tee tiles built into the walls and roof, similar floor elements being housed in specially shaped sillimanite bricks, covered with a heavy Cronite hearth plate. A gas curtain, automatically controlled by the opening and closing of the door, reduces heat losses when the door is opened.

Stress Relieving

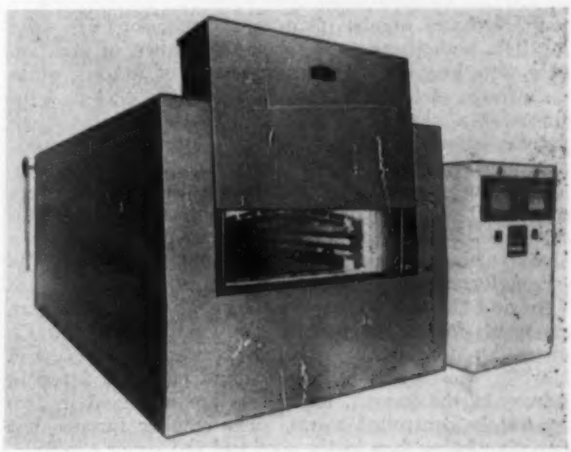
In order to satisfy customers' requirements, many castings must be stress relieved; this is also true of welded constructions which are being used to an increasing extent to-day. Considerable care is necessary in the heat treatment given to remove internal stresses, and while many conventional types of furnaces are used for this purpose, owing to the shape or size of the component to be treated, special arrangements must be made to carry out the operation successfully. An interesting example concerns the fabrication of bottom-half turbine exhaust casings for two 200 MW. turbo generators in course of manufacture by G.E.C. for extensions to the Kincardine generating station of the South of Scotland Electricity Board. It was decided to fabricate each set as a complete unit and carry out the stress relieving by electric heating. This was a departure from normal G.E.C. practice on large reheat turbo generators where the exhaust casings have previously been made in sections and stress relieved in conventional furnaces before bolting together as a complete component. Each of the Kincardine casings is 47 tons in weight with overall dimensions of 21 ft. 3 in. × 17 ft. × 8 ft. 3 in. high.

Due to the amount of metal and the complicated nature of the structure, calculations showed that it was necessary to use 68 single-phase radiant heating elements each of $7\frac{1}{2}$ kW. rating. The positions of the heaters within the casing were carefully arranged to ensure even heating throughout the structure, and each one had individual control. The casing was placed on a firebrick base and the majority of the heating elements were sus-



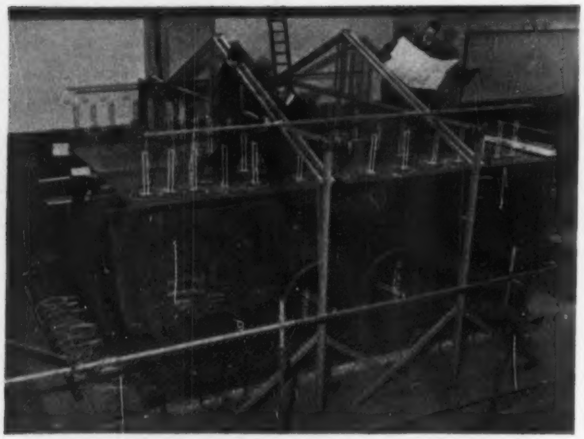
Courtesy of Northern Aluminium Co., Ltd.

Fig. 9.—A conveyorised gas-fired furnace for preheating aluminium alloy ingots, using air circulation heating. It was designed and built by J.L.S. Engineering Co., Ltd.



Courtesy of Hedin, Ltd.

Fig. 10.—New preheating box furnace for operation at temperatures up to 1,000° C.



Courtesy of The General Electric Co., Ltd.

Fig. 11.—Showing the application of radiant heat for stress relieving large turbine exhaust casing weldments.

pended vertically inside, although a number were floor mounted at predetermined strategic points. After covering the open top with a ½ in. steel plate, the whole structure was encased in thermal insulation to a depth of 6 in. Forty-two thermocouples, disposed about the casing, were connected to seven 6-point graphic recorders for temperature measurements. It was thus possible to record average conditions in the whole casing during the heating operation, and individual heaters were switched to maintain uniform heating. When the temperature reached 650° C., the power input was reduced to keep the temperature constant while the casing "soaked" for three hours, after which the heaters were switched off and it was allowed to cool to ambient temperature. One of the casings being prepared for stress relieving is shown in Fig. 11; some of the radiant electric heaters can be seen through the openings in the side of the casing.

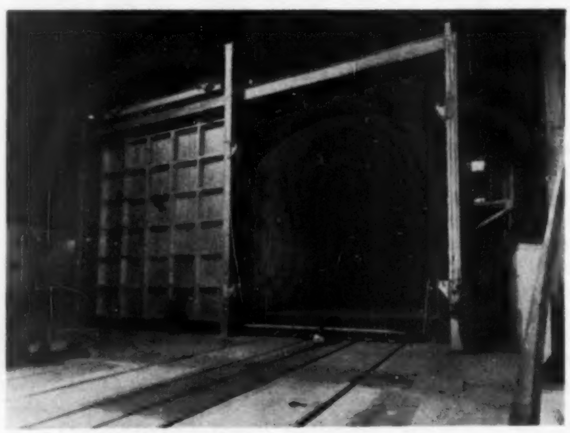
A more conventional furnace for the treatment of weldments has recently been installed by Dowson and Mason, Ltd., at the Derby Works of the International Combustion Co., Ltd., as part of their large shop extensions. The installation comprises two gas-fired bogie hearth furnaces, one having internal dimensions 8 ft. wide × 10 ft. high (from top of bogie to crown of arch) × 42 ft. 8 in. long, for a maximum charge of 70 tons, while the other is 14 ft. wide × 14 ft. 6 in. high × 24 ft. 4 in. long, for a charge of 25 tons. Both furnaces have automatic temperature control equipment with programme regulation.

A Metalectric installation specially designed for stress relieving induction hardened track links comprises two furnaces. Both have conveyors consisting of four chains across which slats are fitted to carry the work. The larger furnace handles 15 cwt./hr. of the larger size links and the smaller one 5 cwt./hr. Both furnaces are designed for a maximum temperature of 450° C., operating temperatures being between 180° C. and 250° C. Heating is by wire wound elements fitted in frames in the hearth, and these are arranged in two separately controlled zones. The smaller furnace has two circulating fans in the roof and the larger one four. With a heated length of 9 ft., the smaller furnace is rated at 40 kW., the corresponding figures for the larger unit being 26 ft. and 110 kW. Each furnace is fitted with a cooling canopy at the discharge end, and is drawn over the charge by a fan fitted in the roof.

Fig. 12 shows one of the largest bogie hearth stress relieving furnaces ever built in this country. Fired by town's gas, it has internal dimensions 21 ft. 6 in. wide × 21 ft. 6 in. high (from top of bogie to crown of arch) × 40 ft. long, the bogie being designed for a maximum charge of 100 tons. The temperature is automatically controlled in three zones. In order to obtain a closer degree of temperature uniformity in a chamber of this size, burners are fitted at the base of the rear wall and across the front of the bogie in addition to those in the side walls. The side traversing door is electrically operated and has an hydraulic clamping mechanism to maintain a good seal to the front of the furnace. This furnace has been built at the works of Vickers-Armstrong, Ltd., Barrow-in-Furness.

A further example of the use of electric radiant heaters is concerned with the stress relieving of reactor pressure vessels erected at the Berkeley nuclear power station, supervised by the Electric Resistance Furnace Co., Ltd. It involved the task of heat treating a mild steel vessel weighing 1,000 tons in one operation. For this purpose equipment was installed requiring a 2½ MW. power supply. The vessels, each being 80 ft. high, 50 ft. in diameter and of 142,000 cu. ft. capacity, were erected on site from sections of 3 in. and 4 in. thick mild steel plate, the erection involving 2,500 ft. of welds per vessel. The huge steel diagrids to support the nuclear piles weigh 165 tons. Problems involved in the heating included making allowances for changes in shape and size as the vessels were heated, accurate measurement and control of temperature from a remote position, and the installation of the heating equipment in a humid atmosphere caused by the setting concrete of the outer biological shield.

Each vessel and its diagrid was heated by 8,500 ft. of sheathed radiant heaters mounted on specially designed supports erected within the vessel which was covered externally with Caposite and Rocksill insulation. The electricity supply to the heaters was carried by a com-



Courtesy of Dowson and Mason, Ltd.

Fig. 12.—A stress relieving furnace claimed to be one of the largest installed in this country.

plicated system of busbars entering the vessel through gas ports which were then closed to reduce heat losses. The heaters were arranged in twenty-four independently controlled zones, the twenty-four automatic temperature controllers together with four 6-point temperature recorders, being installed in a separate control room. Some four hundred thermocouples were used in the measuring, controlling and recording of temperatures. The complete stress relieving operation, involving heating to the minimum specified temperature of 575° C., holding at temperature and cooling to atmospheric temperature, took approximately fourteen days per vessel.

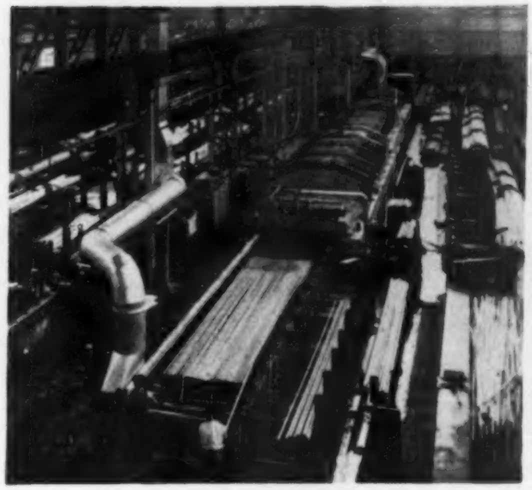
A controlled atmosphere mesh belt conveyor furnace for the stress relieving of cold rolled grain oriented silicon steel sheets has been installed by Metalectric Furnaces, Ltd., complete with associated atmosphere generator. The furnace, which is rated at 250 kW. has a belt width of 40 in. and is capable of an output of ½ ton of sheets per hour. It is designed for the short cycle process and is the latest and largest of its type pioneered and developed by Metalectric. The atmosphere plant is a 2,000 cu. ft./hr. nitrogen generator, producing an atmosphere in excess of 99% nitrogen, which is, in this instance, mounted above the cooling section of the furnace, thereby conserving floor space and providing a compact and clean line installation. Water cooling equipment for both furnace and atmosphere plant is also included.

Annealing

One of the largest heat treatment installations in the country, recently put into commission at the Duston Works of British Timken, forms a continuous line for the heat treatment of bearing rings, cups and cones. It comprises a continuous triple track gas carburising furnace, a pusher-type sub-critical annealing furnace, a roller hearth furnace for hardening, and a slat conveyor furnace for tempering. Protective atmosphere for the furnaces is supplied by two 2,000 cu. ft./hr. endothermic generators and a 1,500 cu. ft./hr. exothermic generator. It seems appropriate to refer briefly to the annealing furnace under the above heading and to other furnaces in the installation elsewhere in the text under the appropriate headings.

Timken roller bearing parts are sub-critically annealed in a Birlec 45 kW. pusher furnace, in which the tape heating elements are arranged in three zones. Cups and cones annealed in this furnace are subjected to a seven hour heat treatment cycle: the maximum temperature attainable is 750° C. The operation of the annealing furnace is controlled by the automatic cycle of the carburising furnace. Components from the washing station are transferred automatically to the annealing furnace. Cooling of the charge after annealing takes place in a special cooling chamber, and fast drive discharge rollers are used to transfer the trays rapidly from the heating chamber.

In recent years Northern Aluminium Co., Ltd., have commissioned much new plant in their factories. Typical of this is the large electric furnace installed at the Banbury works. Previously, the Banbury mills engaged in producing aluminium sheet could roll a maximum width of 5 ft. The new mills can produce widths of up to 6 ft. 6 in. and the new furnace has been specially designed and built by G.W.B. Furnaces, Ltd., to fit in with this development. Ingots 8 in. thick are hot rolled down to approximately 0·3–0·5 in. Work hardening



Courtesy of G.W.B. Furnaces, Ltd.

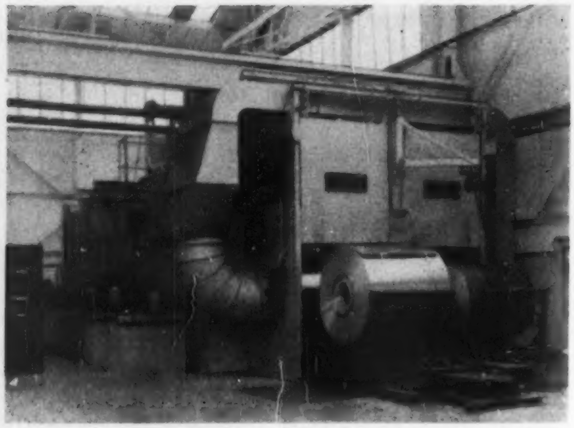
Fig. 13.—Overall front view of the 166 ft. long roller hearth furnace.

takes place and annealing is necessary before rolling the slabs to lighter gauges.

Loads of 16 tons for slab lengths of 65 ft. and widths of 6 ft. 6 in. can be accommodated in this furnace, which has a rating of 1,000 kW. distributed over six independent and automatically controlled zones of equal length. The maximum temperature is 600° C., although normal operating temperatures are somewhat lower. The high rating enables cycle times as low as 4 hours to be achieved. Six air circulating fans are located on the furnace roof, each capable of delivering 30,000 cu. ft. of air per minute. A slow cool is necessary for fully annealed material; to ensure this, a cooling chamber similar in size to the heating chamber has been incorporated in the installation. Six fan units are again provided, one per zone, with the necessary ducting to direct the air flow into the chamber. Serving both furnace and cooling chamber is a single track charging machine, which is designed to work in conjunction with roller-fitted charge skips.

Three similar roller hearth furnaces have recently been installed at Yorkshire Imperial Metals, Ltd., of Leeds. The latest of these, shown in Fig. 13, is designed to deal with very long lengths of tubing and has an overall length itself of over 166 ft. The furnace is used for the bright annealing of copper and annealing most types of brass tube in straight lengths, and copper tube in coils. Tubes in straight lengths up to 35 ft., from ½ in. O.D. by 20 s.w.g. to 4 in. O.D. by ¼ in. thick, and coils 5 ft. 9 in. in diameter, 6 ft. high, and weighing 150 lb. may be treated. By using extensions to the loading and unloading tables, conical tanker tubes, 80 ft. in length, have been treated. When annealing straight copper housing tube ½ in. O.D. by 20 s.w.g., an output of 2·85 tons/hr. has been obtained, while for brass tanker heater tube 1¼ in. O.D. by 14 s.w.g. the output was 2·87 tons/hr.

The equipment has an electrical rating of 550 kW. arranged in four automatically controlled zones. The heating chamber is 25 ft. long and can accommodate charges up to 9 in. in height and 6 ft. 6 in. wide. A water jacketed cooling chamber 50 ft. long is fitted at

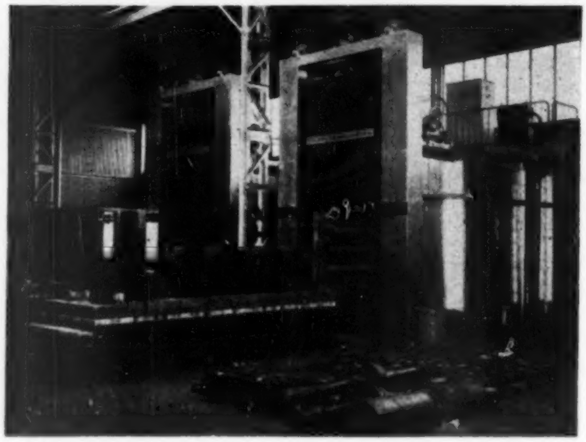


Courtesy of Stordy Engineering, Ltd.

Fig. 14.—A regenerative type annealing furnace for aluminium coils.

the exit end of the heating zone and discharge vestibule so that the charge may be cooled gradually. To provide the correct degree of heat balance from one end of the unit to the other, and to provide a gas seal when using protective atmosphere, an entry zone 13 ft. 6 in. long is provided. All rollers are power driven; those in the heating and cooling chambers are of heat resisting alloy, whilst the remainder are of mild steel. The installation includes a burnt town's gas plant, having a capacity of 1,000 cu. ft./hr., for use when a protective atmosphere is necessary.

A regenerative type annealing furnace (Fig. 14) forms part of a £1 million development scheme recently completed by Birmetals, Ltd.; it is designed to handle aluminium coils weighing up to 8,000 lb. each and having a maximum diameter of 53 in. This furnace comprises a cooling chamber, three preheating chambers and the furnace chamber proper, each compartment being isolated from the adjoining ones by means of vertical rising insulated doors which have a motorised operation from an adjustable timer. The principle around which this furnace has been developed is to make use of the heat in the annealed coils for preheating the coils to be annealed; the furnace has, therefore, been provided with an ingoing lane which, through the cooling section and the three preheat zones, comprises a roller path on which the stillage with the coil is carried; a similar roller path being provided on the outgoing lane which is parallel to the ingoing one. Over the furnace section proper, which is designed to contain four stillages, the hearth is formed of heat resisting cast iron with a developed system of guides engaging with the stillage faces. A pusher gear at the ingoing position engages the stillage face and the line of stillages is progressed through the various preheat zones to the furnace proper. At the last station in the furnace section a transverse pusher gear is provided, with further pusher gear to progress the stillages through the outgoing lane. At the discharge table is an overhead hoist on a swinging jib arranged to transfer the unloaded stillages to the loading position. Each of the preheat zones in this furnace is provided with a 50 kW. boost heater which is primarily designed to operate when the furnace is first charged and when there are no hot coils available. The furnace proper is provided with two centrifugal fans, each fan circuit being complete with a 200 kW. heater mounted in the supply duct system.



Courtesy of Metalectric Furnaces, Ltd.

Fig. 16.—Two bogie hearth furnaces installed for heat treating steel forgings.

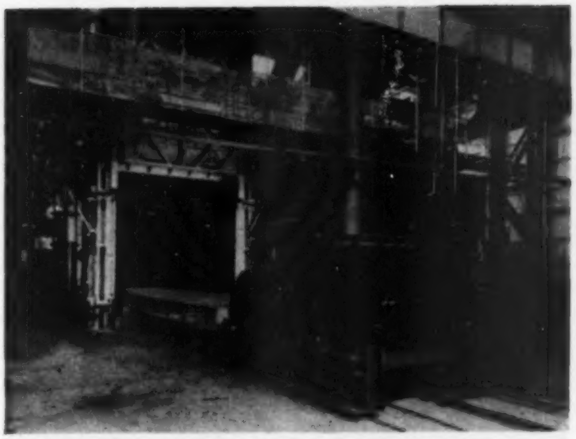
A battery of batch type coil and sheet annealing furnaces has been installed at the Resolven Works of Reynolds T.I. Aluminium, each of which is designed to handle a charge load of up to 50 tons of coil or plate

pheric conditions being maintained in the third furnace. The rating of each furnace is 1,800 kW. arranged as six separate batteries, each of 300 kW., this rating being further sub-divided so that a heating pattern to suit load and temperature can be arranged with three-position control to avoid hunting at the control point. The heater batteries are disposed at each side of the work chamber, but remote from it, and they can be removed as complete units for maintenance purposes. Each furnace is further provided with three axial-flow high temperature circulating fans of known pressure/volume characteristic and designed to give temperature limits at control point of $\pm 2\frac{1}{2}°$ C. A general view of the plant is shown in Fig. 15.

Two electric bogie hearth furnaces have recently been installed for annealing steel forgings in the temperature range 800–1,000° C. Each furnace, rated at 385 kW., has usable dimensions 5 ft. wide over the bogie deck × 5 ft. high to spring of door arch and a heated length of 14 ft. The general arrangement of this installation is shown in Fig. 16. The bogies are designed for a gross charge of 10 tons each, made up of components of average weight 1 ton each and a maximum individual weight of 2 tons. Special attention was given to the distribution of the heavy gauge nickel-chrome tape heating elements to ensure maximum temperature uniformity conditions within the heating chamber.

Two coil annealing furnaces at the Rogerstone Works of Northern Aluminium Co., Ltd., are shown in Fig. 17. Each unit is 28 ft. long × 10 ft. 6 in. wide, and will hold a load of 250,000 lb. of coils stacked to a height of about 150 in. The coils rest on stillages carried in the furnace on bogies, which are hauled in and out by a mobile tractor. The furnaces are fired with light oil in radiant tubes of inverted "U" form, which are arranged along each side of the furnace. These tubes operate at negative pressure, thus eliminating any risk of contamination of the recirculated atmosphere by products of combustion. Eight atmosphere fans, of very high capacity, are provided in the roof of each furnace. The circulation is from a special plenum chamber formed by the bogie and stillage, through the coils to the fans and from the fans to the side chambers containing the radiant tubes. The furnace doors are operated by electric motors with inching control, the periphery of the door being sealed against a water-cooled hose forming a completely gas-tight seal. An atmosphere gas plant is included for use with these furnaces.

The portable cover furnace is widely used to meet closely controlled conditions in the heat treatment of modern mill rolls and Fig. 18 is a rather interesting example. Installed at the Crewe Works of Midland Rollmakers, Ltd., it is designed to carry three hoods, 13 ft. 3 in., 16 ft. 9 in. and 32 ft. 6 in. in length, respectively, and one common base or hearth of an overall length to suit the longest of the three hoods. The two shorter hoods can be used together or singly and comprise in effect two independent and separate furnaces



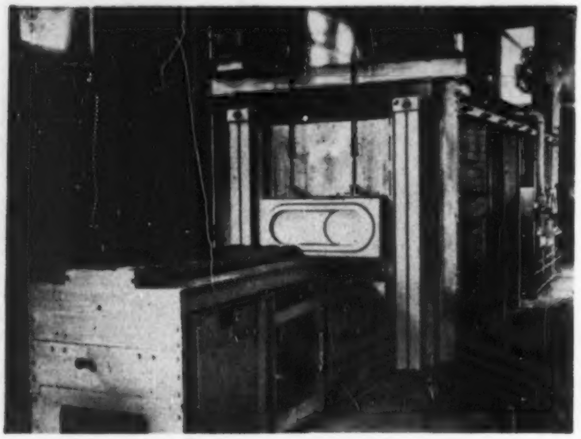
Courtesy of Stein and Atkinson, Ltd.

Fig. 17.—Coil annealing furnaces installed at the Rogerstone Works of Northern Aluminium Co., Ltd.

hood in accordance with the length of the rolls greatly improves production versatility and effects economy of fuel as well as of floor space.

Reference to the Jetube system of firing furnaces has been made in earlier issues. A furnace designed for annealing stainless steel pressings, has recently been installed (Fig. 19) in which the work is heated to a temperature of 1,080° C. by two Jetube radiant heating elements, fired by town's gas and arranged longitudinally above and below the conveyor. The Jetubes are fitted with automatic temperature control, and each has its own gas and air calibrating valves. The heated length is 5 ft., the cooling zone 15 ft., and the belt is 12 in. wide. When used for clean annealing of stainless steel the output is 100 lb./hr.; copper is bright annealed in the same furnace at an output of 250 lb./hr.

Site erection of a heavy duty Birlec roller hearth furnace for annealing steel coils, and its associated gas plant, is nearing completion. It has been designed and built to the order of the Whitehead Iron and Steel Co., Ltd., for the treatment of coils up to 4 ft. diameter and

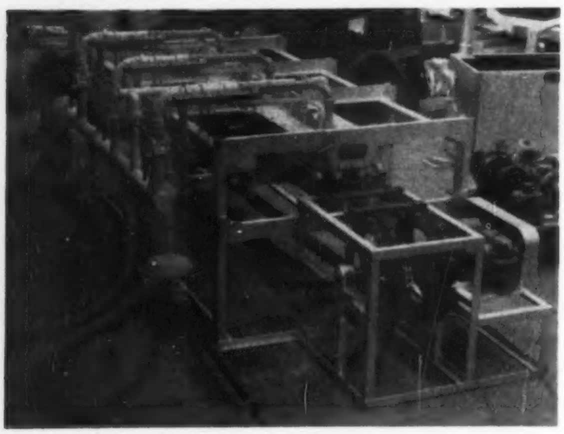


Courtesy of The Incandescent Heat Co., Ltd.

Fig. 6.—A continuous pusher furnace for heating billets for forging.

used, combustion being established in two combustion chambers at each end of the furnace. The furnace pressure is controlled by automatic operation of the furnace main dampers and the temperature in the furnace is continuously recorded by a 6-point recording pyrometer with a 0–1,600° C. range. Reversal signalling equipment is provided incorporating a 2-point, 2-zone recording pyrometer and reversals of fuel, air and waste gases are push button operated. Gas flow is indicated and continuously recorded whilst air flow is only indicated. All instruments are panel mounted and installed in an instrument house.

Another example of billet heating is provided by the continuous pusher furnace shown in Fig. 6; it is used for heating billets for forging and is fired by preheated fuel oil having a viscosity of 90–100 sec. Redwood No. 1 at the burner. The furnace is 3 ft. 6 in. wide between the side walls and the heating chamber is 21 ft. 6 in. long. The heating chamber is divided into a preheating zone and a final heating and soaking zone. Two burners in the discharge end wall fire over the final

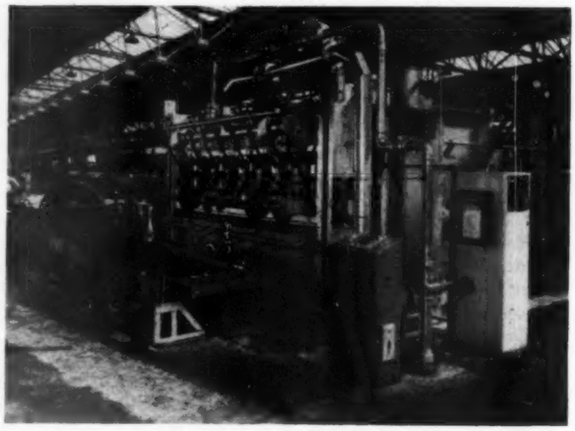


Courtesy of Dowson and Mason, Ltd.

Fig. 7.—A furnace specially designed for the centre "nibbing" of leaf spring plate.

heating and soaking hearth. Transverse firing is arranged in the preheat section, using burners fitted in staggered formation in the side walls. The furnace and pusher are 35 ft. long and 10 ft. 6 in. wide overall, and the installation is designed for an output of 50 cwt./hr.

A specialised type of furnace recently installed at the Crewe Works of the British Transport Commission is that shown in Fig. 7. It is used in connection with the centre "nibbing" of leaf spring plates. Although this process is frequently performed cold, the life of the press tools is much prolonged if the plates are heated. The furnace is designed to heat the centre of the plates only, the heated length being approximately 3 in., the ends remaining comparatively cold. Heating is by multiple jet type burners firing vertically downwards, giving hot gas and flame impingement on the spring plates. The conveyor is motor driven with a variable speed reduction gear. This furnace, which has an overall length of 16 ft. 6½ in. and is 6 ft. 3 in. wide, is designed for an output of a hundred plates an hour,



Courtesy of Stein and Atkinson, Ltd.

Fig. 8.—A dual-purpose furnace for the production of large copper tubes.

measuring 5 in. wide × ⅜ in. thick and varying from 8 in. to 4 ft. 6 in. in length.

The production of large copper tubes by extrusion sometimes requires a dual-purpose furnace, firstly to heat the billets for piercing and partial forming, and secondly to heat the partly formed tubes for further expansion before the drawbench. The furnace shown in Fig. 8, installed at Wednesbury Tube Works, is designed for this purpose. In this case the billets or tubes are charged singly (two rows of billets or a single row of tubes) on to a series of alloy steel arms which carry them forward into the furnace. At the end of each forward stroke the stock is deposited on the hearth and the arms are turned through 90° so that they pass under the stock ready for the next forward movement. The arms are again turned through 90° to the original position, whereupon they lift the stock off the hearth and carry it forward another stroke. The stock is finally discharged down a slope to the table taking it to the extrusion press. All motions are operated by oil/hydraulic equipment. The furnace is fired with town's gas with burners at the

discharging end, and is automatically controlled for temperature and fuel/air ratio. It has an output of $2\frac{1}{2}$ tons/hr.

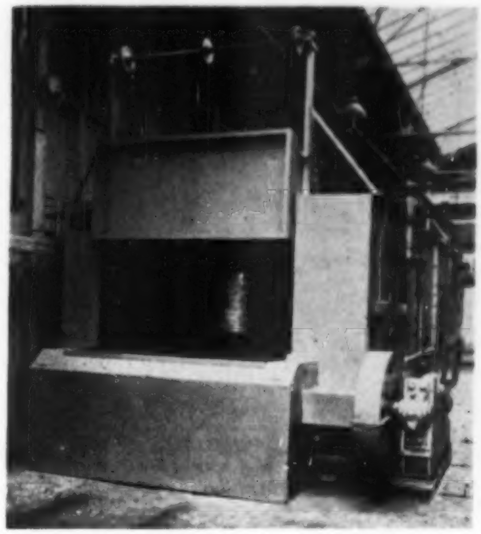
The use of air circulation heating for aluminium and aluminium alloys is increasing in popularity, and the conveyorised gas-fired furnace shown in Fig. 9 incorporates the J.L.S. patented air circulating system, which gives a very high degree of temperature uniformity throughout the working space. This furnace is designed chiefly for preheating aluminium alloy ingots prior to hot working. It has a capacity of 15 tons, which is normally formed of ingots 6 ft. by 4 ft. by 2 ft. As will be noted from the illustration, the furnace is not confined to preheating, but may be used for annealing or any other form of heat treatment required by aluminium and its alloys. The design of this furnace constitutes a major departure from the conventional type of unit constructed of refractory brick. In this case, the inner and outer casings are of steel plate, with steel wool or similar insulation in between. In addition to high thermal insulation, achieved with low thermal storage, the double cased form of wall construction has greatly reduced running costs. Although the furnace illustrated is gas fired, electricity or oil may be used as the heating medium.

A new preheating box furnace, for operation at temperatures up to 1,000° C. is shown in Fig. 10; it has an effective heating zone 10 ft. long × 4 ft. wide × 1 ft. 3 in. high. Included among the specifications around which the furnace was designed were (*a*) the temperature distribution throughout the furnace to be within ±5° C.; (*b*) a 15 minute recovery time without overshoot was required for reheating billets after rolling; and (*c*) the furnace lines were to be in keeping with modern design. In order to give quick recovery time and also close temperature control, the furnace was designed with two zones, each of 75 kW. Each zone is controlled by means of a Honeywell Brown potentiometric type temperature controller and saturable reactor. As will be noted in the illustration, the furnace has been given a streamlined appearance. The nickel-chrome tape elements are housed in sillimanite tee tiles built into the walls and roof, similar floor elements being housed in specially shaped sillimanite bricks, covered with a heavy Cronite hearth plate. A gas curtain, automatically controlled by the opening and closing of the door, reduces heat losses when the door is opened.

Stress Relieving

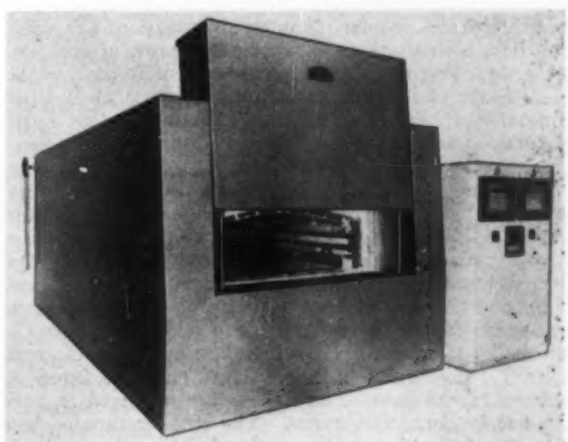
In order to satisfy customers' requirements, many castings must be stress relieved; this is also true of welded constructions which are being used to an increasing extent to-day. Considerable care is necessary in the heat treatment given to remove internal stresses, and while many conventional types of furnaces are used for this purpose, owing to the shape or size of the component to be treated, special arrangements must be made to carry out the operation successfully. An interesting example concerns the fabrication of bottom-half turbine exhaust casings for two 200 MW. turbo generators in course of manufacture by G.E.C. for extensions to the Kincardine generating station of the South of Scotland Electricity Board. It was decided to fabricate each set as a complete unit and carry out the stress relieving by electric heating. This was a departure from normal G.E.C. practice on large reheat turbo generators where the exhaust casings have previously been made in sections and stress relieved in conventional furnaces before bolting together as a complete component. Each of the Kincardine casings is 47 tons in weight with overall dimensions of 21 ft. 3 in. × 17 ft. × 8 ft. 3 in. high.

Due to the amount of metal and the complicated nature of the structure, calculations showed that it was necessary to use 68 single-phase radiant heating elements each of $7\frac{1}{2}$ kW. rating. The positions of the heaters within the casing were carefully arranged to ensure even heating throughout the structure, and each one had individual control. The casing was placed on a firebrick base and the majority of the heating elements were sus-



Courtesy of Northern Aluminium Co., Ltd.

Fig. 9.—A conveyorised gas-fired furnace for preheating aluminium alloy ingots, using air circulation heating. It was designed and built by J.L.S. Engineering Co., Ltd.



Courtesy of Hedin, Ltd.

Fig. 10.—New preheating box furnace for operation at temperatures up to 1,000° C.

Courtesy of The General Electric Co., Ltd.

Fig. 11.—Showing the application of radiant heat for stress relieving large turbine exhaust casing weldments.

pended vertically inside, although a number were floor mounted at predetermined strategic points. After covering the open top with a ½ in. steel plate, the whole structure was encased in thermal insulation to a depth of 6 in. Forty-two thermocouples, disposed about the casing, were connected to seven 6-point graphic recorders for temperature measurements. It was thus possible to record average conditions in the whole casing during the heating operation, and individual heaters were switched to maintain uniform heating. When the temperature reached 650° C., the power input was reduced to keep the temperature constant while the casing " soaked " for three hours, after which the heaters were switched off and it was allowed to cool to ambient temperature. One of the casings being prepared for stress relieving is shown in Fig. 11 ; some of the radiant electric heaters can be seen through the openings in the side of the casing.

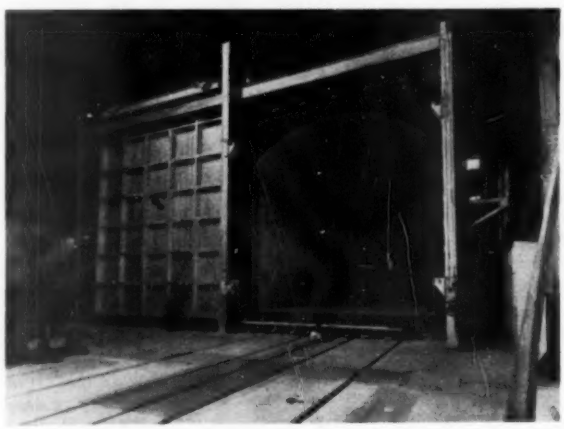
A more conventional furnace for the treatment of weldments has recently been installed by Dowson and Mason, Ltd., at the Derby Works of the International Combustion Co., Ltd., as part of their large shop extensions. The installation comprises two gas-fired bogie hearth furnaces, one having internal dimensions 8 ft. wide × 10 ft. high (from top of bogie to crown of arch) × 42 ft. 8 in. long, for a maximum charge of 70 tons, while the other is 14 ft. wide × 14 ft. 6 in. high × 24 ft. 4 in. long, for a charge of 25 tons. Both furnaces have automatic temperature control equipment with programme regulation.

A Metalectric installation specially designed for stress relieving induction hardened track links comprises two furnaces. Both have conveyors consisting of four chains across which slats are fitted to carry the work. The larger furnace handles 15 cwt./hr. of the larger size links and the smaller one 5 cwt./hr. Both furnaces are designed for a maximum temperature of 450° C., operating temperatures being between 180° C. and 250° C. Heating is by wire wound elements fitted in frames in the hearth, and these are arranged in two separately controlled zones. The smaller furnace has two circulating fans in the roof and the larger one four. With a heated length of 9 ft., the smaller furnace is rated at 40 kW., the corresponding figures for the larger unit being 26 ft. and 110 kW. Each furnace is fitted with a cooling canopy at the discharge end, and is drawn over the charge by a fan fitted in the roof.

Fig. 12 shows one of the largest bogie hearth stress relieving furnaces ever built in this country. Fired by town's gas, it has internal dimensions 21 ft. 6 in. wide × 21 ft. 6 in. high (from top of bogie to crown of arch) × 40 ft. long, the bogie being designed for a maximum charge of 100 tons. The temperature is automatically controlled in three zones. In order to obtain a closer degree of temperature uniformity in a chamber of this size, burners are fitted at the base of the rear wall and across the front of the bogie in addition to those in the side walls. The side traversing door is electrically operated and has an hydraulic clamping mechanism to maintain a good seal to the front of the furnace. This furnace has been built at the works of Vickers-Armstrong, Ltd., Barrow-in-Furness.

A further example of the use of electric radiant heaters is concerned with the stress relieving of reactor pressure vessels erected at the Berkeley nuclear power station, supervised by the Electric Resistance Furnace Co., Ltd. It involved the task of heat treating a mild steel vessel weighing 1,000 tons in one operation. For this purpose equipment was installed requiring a 2½ MW. power supply. The vessels, each being 80 ft. high, 50 ft. in diameter and of 142,000 cu. ft. capacity, were erected on site from sections of 3 in. and 4 in. thick mild steel plate, the erection involving 2,500 ft. of welds per vessel. The huge steel diagrids to support the nuclear piles weigh 165 tons. Problems involved in the heating included making allowances for changes in shape and size as the vessels were heated, accurate measurement and control of temperature from a remote position, and the installation of the heating equipment in a humid atmosphere caused by the setting concrete of the outer biological shield.

Each vessel and its diagrid was heated by 8,500 ft. of sheathed radiant heaters mounted on specially designed supports erected within the vessel which was covered externally with Caposite and Rocksill insulation. The electricity supply to the heaters was carried by a com-



Courtesy of Dowson and Mason, Ltd.

Fig. 12.—A stress relieving furnace claimed to be one of the largest installed in this country.

plicated system of busbars entering the vessel through gas ports which were then closed to reduce heat losses. The heaters were arranged in twenty-four independently controlled zones, the twenty-four automatic temperature controllers together with four 6-point temperature recorders, being installed in a separate control room. Some four hundred thermocouples were used in the measuring, controlling and recording of temperatures. The complete stress relieving operation, involving heating to the minimum specified temperature of 575° C., holding at temperature and cooling to atmospheric temperature, took approximately fourteen days per vessel.

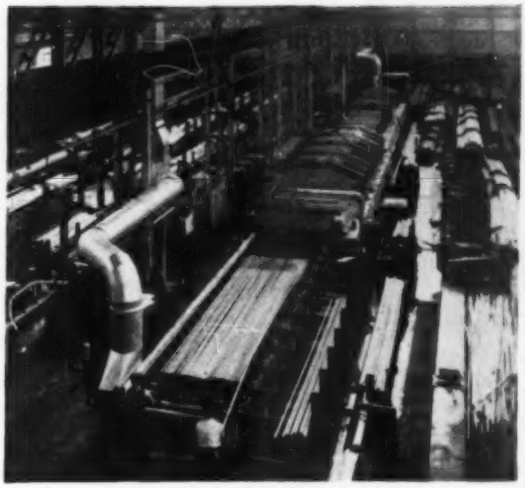
A controlled atmosphere mesh belt conveyor furnace for the stress relieving of cold rolled grain oriented silicon steel sheets has been installed by Metalectric Furnaces, Ltd., complete with associated atmosphere generator. The furnace, which is rated at 250 kW. has a belt width of 40 in. and is capable of an output of ½ ton of sheets per hour. It is designed for the short cycle process and is the latest and largest of its type pioneered and developed by Metalectric. The atmosphere plant is a 2,000 cu. ft./hr. nitrogen generator, producing an atmosphere in excess of 99% nitrogen, which is, in this instance, mounted above the cooling section of the furnace, thereby conserving floor space and providing a compact and clean line installation. Water cooling equipment for both furnace and atmosphere plant is also included.

Annealing

One of the largest heat treatment installations in the country, recently put into commission at the Duston Works of British Timken, forms a continuous line for the heat treatment of bearing rings, cups and cones. It comprises a continuous triple track gas carburising furnace, a pusher-type sub-critical annealing furnace, a roller hearth furnace for hardening, and a slat conveyor furnace for tempering. Protective atmosphere for the furnaces is supplied by two 2,000 cu. ft./hr. endothermic generators and a 1,500 cu. ft./hr. exothermic generator. It seems appropriate to refer briefly to the annealing furnace under the above heading and to other furnaces in the installation elsewhere in the text under the appropriate headings.

Timken roller bearing parts are sub-critically annealed in a Birlec 45 kW. pusher furnace, in which the tape heating elements are arranged in three zones. Cups and cones annealed in this furnace are subjected to a seven hour heat treatment cycle: the maximum temperature attainable is 750° C. The operation of the annealing furnace is controlled by the automatic cycle of the carburising furnace. Components from the washing station are transferred automatically to the annealing furnace. Cooling of the charge after annealing takes place in a special cooling chamber, and fast drive discharge rollers are used to transfer the trays rapidly from the heating chamber.

In recent years Northern Aluminium Co., Ltd., have commissioned much new plant in their factories. Typical of this is the large electric furnace installed at the Banbury works. Previously, the Banbury mills engaged in producing aluminium sheet could roll a maximum width of 5 ft. The new mills can produce widths of up to 6 ft. 6 in. and the new furnace has been specially designed and built by G.W.B. Furnaces, Ltd., to fit in with this development. Ingots 8 in. thick are hot rolled down to approximately 0·3–0·5 in. Work hardening takes place and annealing is necessary before rolling the slabs to lighter gauges.



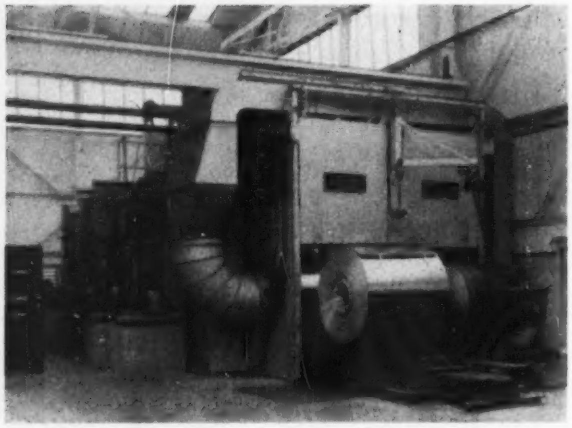
Courtesy of G.W.B. Furnaces, Ltd.

Fig. 13.—Overall front view of the 166 ft. long roller hearth furnace.

Loads of 16 tons for slab lengths of 65 ft. and widths of 6 ft. 6 in. can be accommodated in this furnace, which has a rating of 1,000 kW. distributed over six independent and automatically controlled zones of equal length. The maximum temperature is 600° C., although normal operating temperatures are somewhat lower. The high rating enables cycle times as low as 4 hours to be achieved. Six air circulating fans are located on the furnace roof, each capable of delivering 30,000 cu. ft. of air per minute. A slow cool is necessary for fully annealed material; to ensure this, a cooling chamber similar in size to the heating chamber has been incorporated in the installation. Six fan units are again provided, one per zone, with the necessary ducting to direct the air flow into the chamber. Serving both furnace and cooling chamber is a single track charging machine, which is designed to work in conjunction with roller-fitted charge skips.

Three similar roller hearth furnaces have recently been installed at Yorkshire Imperial Metals, Ltd., of Leeds. The latest of these, shown in Fig. 13, is designed to deal with very long lengths of tubing and has an overall length itself of over 166 ft. The furnace is used for the bright annealing of copper and annealing most types of brass tube in straight lengths, and copper tube in coils. Tubes in straight lengths up to 35 ft., from ½ in. O.D. by 20 s.w.g. to 4 in. O.D. by ¼ in. thick, and coils 5 ft. 9 in. in diameter, 6 ft. high, and weighing 150 lb. may be treated. By using extensions to the loading and unloading tables, conical tanker tubes, 80 ft. in length, have been treated. When annealing straight copper housing tube ½ in. O.D. by 20 s.w.g., an output of 2·85 tons/hr. has been obtained, while for brass tanker heater tube 1½ in. O.D. by 14 s.w.g. the output was 2·87 tons/hr.

The equipment has an electrical rating of 550 kW. arranged in four automatically controlled zones. The heating chamber is 25 ft. long and can accommodate charges up to 9 in. in height and 6 ft. 6 in. wide. A water jacketed cooling chamber 50 ft. long is fitted at

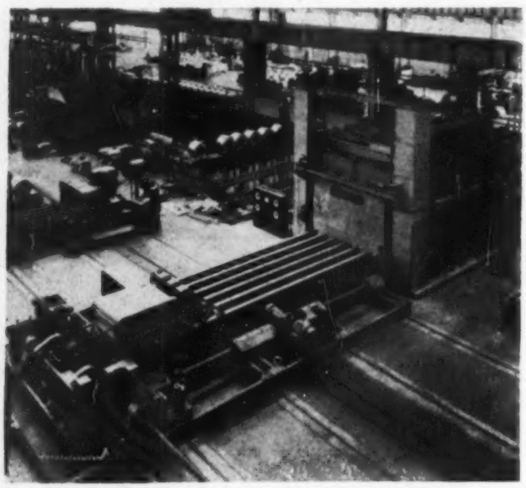


Courtesy of Stordy Engineering, Ltd.

Fig. 14.—A regenerative type annealing furnace for aluminium coils.

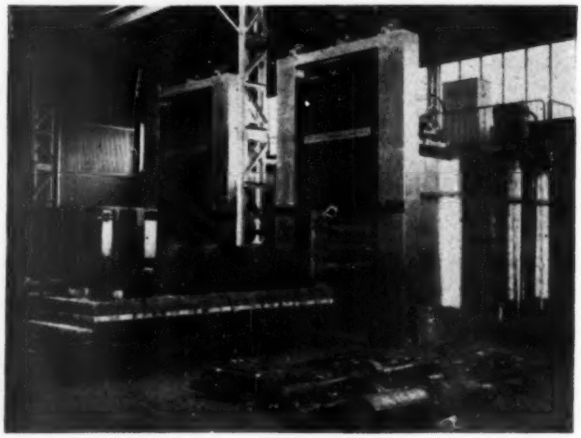
the exit end of the heating zone and discharge vestibule so that the charge may be cooled gradually. To provide the correct degree of heat balance from one end of the unit to the other, and to provide a gas seal when using protective atmosphere, an entry zone 13 ft. 6 in. long is provided. All rollers are power driven; those in the heating and cooling chambers are of heat resisting alloy, whilst the remainder are of mild steel. The installation includes a burnt town's gas plant, having a capacity of 1,000 cu. ft./hr., for use when a protective atmosphere is necessary.

A regenerative type annealing furnace (Fig. 14) forms part of a £1 million development scheme recently completed by Birmetals, Ltd.; it is designed to handle aluminium coils weighing up to 8,000 lb. each and having a maximum diameter of 53 in. This furnace comprises a cooling chamber, three preheating chambers and the furnace chamber proper, each compartment being isolated from the adjoining ones by means of vertical rising insulated doors which have a motorised operation from an adjustable timer. The principle around which this furnace has been developed is to make use of the heat in the annealed coils for preheating the coils to be annealed; the furnace has, therefore, been provided with an ingoing lane which, through the cooling section and the three preheat zones, comprises a roller path on which the stillage with the coil is carried; a similar roller path being provided on the outgoing lane which is parallel to the ingoing one. Over the furnace section proper, which is designed to contain four stillages, the hearth is formed of heat resisting cast iron with a developed system of guides engaging with the stillage faces. A pusher gear at the ingoing position engages the stillage face and the line of stillages is progressed through the various preheat zones to the furnace proper. At the last station in the furnace section a transverse pusher gear is provided, with further pusher gear to progress the stillages through the outgoing lane. At the discharge table is an overhead hoist on a swinging jib arranged to transfer the unloaded stillages to the loading position. Each of the preheat zones in this furnace is provided with a 50 kW. boost heater which is primarily designed to operate when the furnace is first charged and when there are no hot coils available. The furnace proper is provided with two centrifugal fans, each fan circuit being complete with a 200 kW. heater mounted in the supply duct system.



Courtesy of Stordy Engineering, Ltd.

Fig. 15.—Showing one of a battery of batch type coil and sheet annealing furnaces.



Courtesy of Metalectric Furnaces, Ltd.

Fig. 16.—Two bogie hearth furnaces installed for heat treating steel forgings.

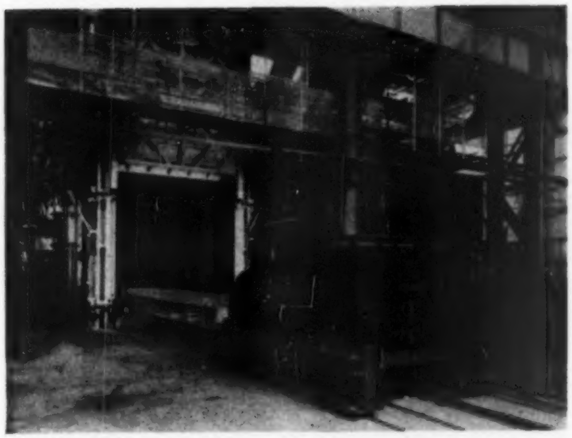
A battery of batch type coil and sheet annealing furnaces has been installed at the Resolven Works of Reynolds T.I. Aluminium, each of which is designed to handle a charge load of up to 50 tons of coil or plate stock and over a temperature range up to a maximum of 600° C. Included with this installation is a 50-ton charging machine, incorporating the Stordy patent lifting motion. Each of the three furnaces comprising this new installation has been designed for inert atmosphere operation, inert gas plant of the Holmes-Kemp pattern, fed with butane/propane rich gas, being provided. The capacity of the gas plant enables two of the furnaces to be purged at one time with atmos-

pheric conditions being maintained in the third furnace. The rating of each furnace is 1,800 kW. arranged as six separate batteries, each of 300 kW., this rating being further sub-divided so that a heating pattern to suit load and temperature can be arranged with three-position control to avoid hunting at the control point. The heater batteries are disposed at each side of the work chamber, but remote from it, and they can be removed as complete units for maintenance purposes. Each furnace is further provided with three axial-flow high temperature circulating fans of known pressure/volume characteristic and designed to give temperature limits at control point of $\pm 2\frac{1}{2}°$ C. A general view of the plant is shown in Fig. 15.

Two electric bogie hearth furnaces have recently been installed for annealing steel forgings in the temperature range 800–1,000° C. Each furnace, rated at 385 kW., has usable dimensions 5 ft. wide over the bogie deck × 5 ft. high to spring of door arch and a heated length of 14 ft. The general arrangement of this installation is shown in Fig. 16. The bogies are designed for a gross charge of 10 tons each, made up of components of average weight 1 ton each and a maximum individual weight of 2 tons. Special attention was given to the distribution of the heavy gauge nickel-chrome tape heating elements to ensure maximum temperature uniformity conditions within the heating chamber.

Two coil annealing furnaces at the Rogerstone Works of Northern Aluminium Co., Ltd., are shown in Fig. 17. Each unit is 28 ft. long × 10 ft. 6 in. wide, and will hold a load of 250,000 lb. of coils stacked to a height of about 150 in. The coils rest on stillages carried in the furnace on bogies, which are hauled in and out by a mobile tractor. The furnaces are fired with light oil in radiant tubes of inverted "U" form, which are arranged along each side of the furnace. These tubes operate at negative pressure, thus eliminating any risk of contamination of the recirculated atmosphere by products of combustion. Eight atmosphere fans, of very high capacity, are provided in the roof of each furnace. The circulation is from a special plenum chamber formed by the bogie and stillage, through the coils to the fans and from the fans to the side chambers containing the radiant tubes. The furnace doors are operated by electric motors with inching control, the periphery of the door being sealed against a water-cooled hose forming a completely gas-tight seal. An atmosphere gas plant is included for use with these furnaces.

The portable cover furnace is widely used to meet closely controlled conditions in the heat treatment of modern mill rolls and Fig. 18 is a rather interesting example. Installed at the Crewe Works of Midland Rollmakers, Ltd., it is designed to carry three hoods, 13 ft. 3 in., 16 ft. 9 in. and 32 ft. 6 in. in length, respectively, and one common base or hearth of an overall length to suit the longest of the three hoods. The two shorter hoods can be used together or singly and comprise in effect two independent and separate furnaces on the one base, since the burner and flue system of the latter is sub-divided into two corresponding and independent sections. This sub-division affords two-zone control when the largest hood is in position. All three hoods are the same width and height, namely, 9 ft. 6 in. × 5 ft. high from hearth level to spring of arch. The burners are for town's gas and fully proportioning temperature control is fitted. The ability to choose the hood in accordance with the length of the rolls greatly improves production versatility and effects economy of fuel as well as of floor space.

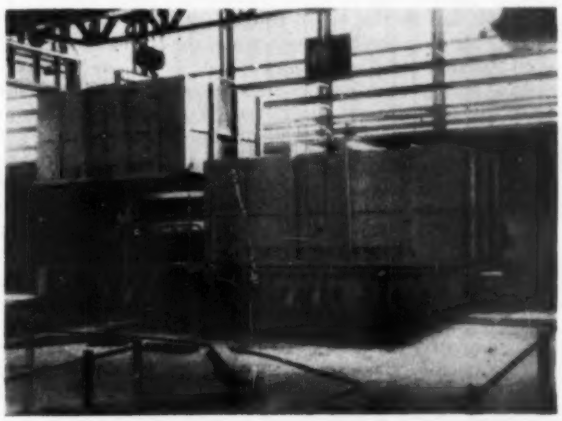


Courtesy of Stein and Atkinson, Ltd.

Fig. 17.—Coil annealing furnaces installed at the Rogerstone Works of Northern Aluminium Co., Ltd.

Reference to the Jetube system of firing furnaces has been made in earlier issues. A furnace designed for annealing stainless steel pressings, has recently been installed (Fig. 19) in which the work is heated to a temperature of 1,080° C. by two Jetube radiant heating elements, fired by town's gas and arranged longitudinally above and below the conveyor. The Jetubes are fitted with automatic temperature control, and each has its own gas and air calibrating valves. The heated length is 5 ft., the cooling zone 15 ft., and the belt is 12 in. wide. When used for clean annealing of stainless steel the output is 100 lb./hr.; copper is bright annealed in the same furnace at an output of 250 lb./hr.

Site erection of a heavy duty Birlec roller hearth furnace for annealing steel coils, and its associated gas plant, is nearing completion. It has been designed and built to the order of the Whitehead Iron and Steel Co., Ltd., for the treatment of coils up to 4 ft. diameter and



Courtesy of Dowson and Mason, Ltd.

Fig. 18.—A "Duplex" portable cover furnace for heat treating mill rolls.

Courtesy of The Incandescent Heat Co., Ltd.

Fig. 19.—A Jetube-fired furnace for annealing stainless steel pressings.

2 ft. high, the estimated weight of the largest being about 4 tons. This steel furnace is almost 350 ft. long and the sections include a loading table, a purging chamber, an inlet tunnel, the main heating chamber, a retarded cooling chamber, a water jacketed cooling chamber and an unloading chamber ; the length of the main heating chamber is 78 ft.

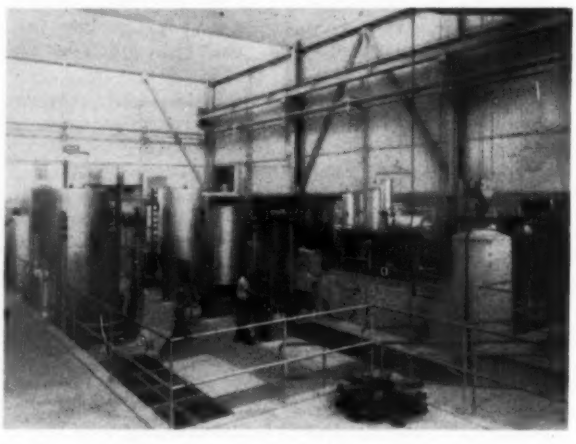
Great attention is now being given to the advantages of vacuum annealing, and a recent bell furnace installation at Dornach, Switzerland, is of particular interest (Fig. 20). This comprises two cylindrical lift-off bell-type furnaces, equipped with four hearths, for annealing copper strip and wire. One hearth for each furnace is designed for vacuum annealing. Each bell is rated at 175 kW. and is heated by wall-mounted type elements. The internal diameter of each furnace is 2 ft. 8 in. and the height 5 ft. 3 in. During vacuum annealing, pumping is carried out intermittently throughout the $3\frac{1}{2}$-hour heating and soaking cycle, and the inner bell is evacuated to a pressure below 1 mm. Hg. No pumping is found to be necessary during the 22-hour cooling period. Two special covers have been provided, each having a powerful fan in the top arranged to force a stream of cooling air over the inner bell when the furnace has been withdrawn.

A new type continuous flash annealing furnace has been installed in the Dolgarrog Works of Aluminium Corporation, Ltd., which is designed to heat rapidly aluminium-manganese alloy circles to produce the fine grain structure needed for deep drawing. Heating is obtained by radiation from heating panels positioned in the roof and hearth, both of which are built as separate units and suspended from the main furnace framework. The furnace, made by Royce Electric Furnaces, Ltd., has a rating of 60 kW. and provides temperatures up to 600° C. The heating chamber is 15 ft. long × 21 in. wide, and the charge is carried through the furnace on an electrically driven horizontal conveyor at a speed variable between 4 and 30 ft./min. The output of circles of 18 s.w.g. material is a little over 2 cwt./hr.

A large bogie hearth furnace installed recently is shown in Fig. 21 : it is designed for a maximum weight charge of 250 tons. The bogie has a nominal hearth area of 12 ft. wide × 50 ft. long, and the door opening is 9 ft. 6 in. to the crown of arch. The furnace, which has an operating temperature range of 100° C. to a maximum of 950° C. is heated by recirculated products of combustion, and large volumes of heated products are continuously recirculated at high velocity through the working chamber. There are six separate combustion chambers mounted on top of the furnace structure and arranged for a total maximum gas consumption of 60,000 cu. ft./hr. : the burner equipment requires air at a pressure of 28 in. W.G. The furnace is arranged for automatic temperature control in six separate zones, and it is fully safeguarded by a series of safety devices. Access to the platform for manipulation and service of the combustion chambers and recirculating fan units is by steel staircases.

A vacuum bell furnace installation has recently been supplied by the Electric Resistance Furnace Co., Ltd., for the bright annealing of copper wire both in coil form and on spools. The use of vacuum treatment for this process is attractive because of the problem of sticking when fine copper wires are bright annealed in controlled atmospheres, and because of the liability to sulphur staining when the wire is annealed on spools. As long cooling times are involved, the bell furnace serves six bases, where 2,500–3,500 lb. charges are accommodated. The furnace is rated at 85 kW. and gives an output of 35 tons of wire per 120-hour week. All the vacuum pumping equipment was designed and manufactured by Edwards High Vacuum, Ltd.

Brayshaw Furnaces, Ltd., have installed two gas and air blast heated oven type bar annealing furnaces at the Sheffield works of Samuel Osborn and Co., Ltd. Each furnace has an operating temperature range of 850°–900° C., and a work chamber 2 ft. 6 in. wide × 1 ft. 6 in. high × 15 ft. long. These units are designed for a maximum gas consumption of approximately 3,500 cu. ft/hr. and attain a temperature of 850° C. in approximately 5 hours with a 4-ton load of bars. Heating is effected by burners of the Brayshaw single lever control proportioning type along the length of the furnace in three banks of ten. They fire into the chamber immediately below the roof and into passages below the



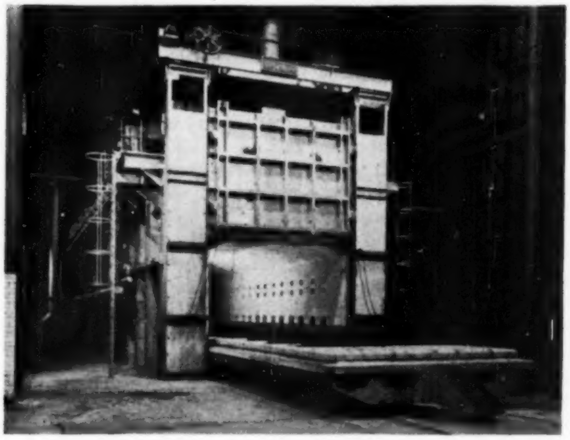
Courtesy of AEI-Birlec, Ltd.

Fig. 20.—A bell-furnace installation for the vacuum annealing of copper strip and wire.

hearth, the products of combustion exhausting at both ends behind the vestibule.

An important innovation in annealing furnace design is reported by Salem Engineering Co., Ltd.; it concerns the use of cooling jets, recently developed by the General Electric Co. of America for which the Salem company are now licensees in the United Kingdom. The design for faster cooling, especially of light-gauge strip, employs a number of self-contained, independent units, each with its own motor-driven blower and heat exchanger. These units force high-velocity cooled gases against, and perpendicular to, each strip surface. The main feature of this development is the marked increase in heat transfer made possible. This increase permits cooling to temperatures lower than any other known dry cooling method. Jet cooling is effective in the temperature range 500°–55° C. for furnaces operating with strip speeds up to 2,000 ft./min. at outputs up to 60 tons/hr. Each of the jet units is readily accessible, providing for simple maintenance and for flexibility of operation.

Efficient combustion depends essentially on achieving and maintaining a constant air/gas ratio. The Brayshaw self proportioning town's gas burner provides a simple arrangement for achieving the initial desired proportion between gas and air supply which is preset by an adjustable port tap. Once set the air/gas ratio remains proportional throughout the range of the burner by the operation of a single lever. The burner is of the Venturi mixing type in which air is supplied through a throat in the burner casting and the gas supply induced from an annulus surrounding the throat, the air/gas mixture burning within a moulded tunnel in the refractory block. The gas supply pressure is regulated by a zero outlet governor, main regulation of the burner being confined to simple adjustment of the air only.

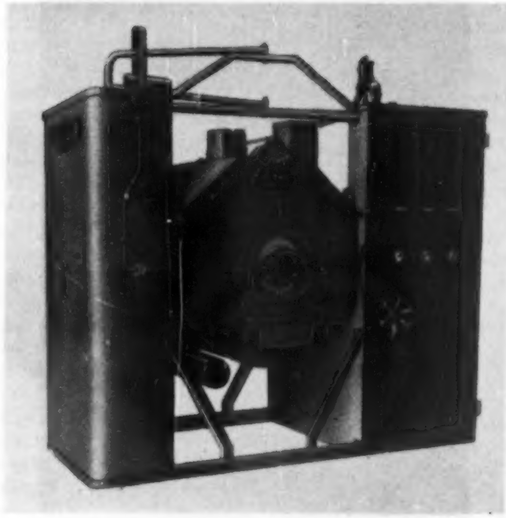


Courtesy of Brayshaw Furnaces, Ltd.

Fig. 21.—A gas and air blast heated bogie hearth furnace designed for annealing a maximum charge weight of 250 tons.

Carburising and Nitriding

A new rotary retort type furnace has been developed by Gibbons Applied Atmospheres, Ltd., in association with Thermic Equipment and Engineering Co., Ltd. It is designed for the batch treatment, in a controlled atmosphere, of parts that are not damaged by a gentle tumbling action. No separate atmosphere generator is necessary for carbonitriding or the clean hardening of high carbon steel parts, the reacted gases being admitted in metered quantities directly to the retort. It is recommended, however, that propane-enriched endothermic gas, supplied by an endothermic generator, is used for gas carburising when a carbonitrided case is not desirable. The advantages of this type of furnace include low capital cost compared with other methods of gas carburising, simplicity, low operating cost, and the short time to bring the furnace into production after a shutdown. Production carburising can be started from cold in under 2½ hours. This type of furnace, shown in Fig. 22, is available in two standard sizes of 150 and 300 lb. capacity, but the range can be extended to include larger sizes. A novel form of quenching for use with this furnace is also available, requiring initially much less oil than does the conventional method, and giving complete control of quench technique and reduced oil usage.



Courtesy of Thermic Equipment and Engineering Co., Ltd.

Fig. 22.—A new type rotary retort furnace for carbonitriding.

New gas carburising plant has been installed in the Darnall Works of Davy and United Engineering Co., Ltd. The installation, shown in Fig. 23, consists of two identical furnaces each providing a working diameter of 4 ft., two endothermic atmosphere generators, oil and water quench tanks, and automatic atmosphere and temperature control gear. The furnaces are heated by gas, the burners being at the bottom of vertical tubes which are dimpled to give maximum heat-transfer efficiency. A fan in the lid of each furnace circulates the carburising atmosphere to ensure intimate contact with all surfaces of the work. The quench tanks are each 10 ft. square × 14 ft. deep and are fitted with circulating pumps. The oil tank also has a heating and cooling system.

A type of furnace which is being increasingly used is the sealed quench equipment; this type offers the advantage of completely controlled atmosphere conditions from the beginning to the end of a heat treatment process, and it is also very versatile in its application, the

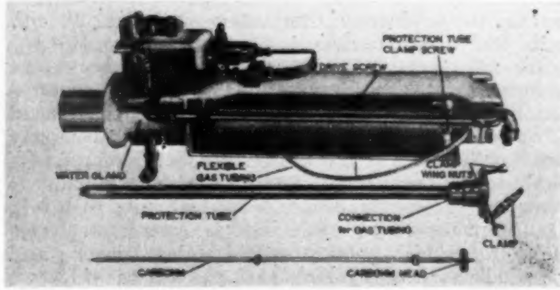
Courtesy of Electric Resistance Furnace Co., Ltd.

Fig. 23.—A general view of the new gas carburising plant installed at the Darnall Works of Davy and United Engineering Co., Ltd.

design being suitable for carburising, carbonitriding, clean hardening and normalising, and carbon restoration. An installation of Wild-Barfield " Ace " furnaces of this type is used for gas carburising automobile transmission components, the atmosphere being propane-enriched endothermic gas. In order to reduce to a minimum the amount of operational supervision, fully automatic dewpoint control is incorporated in the installation. The normal charge space of each furnace is 36 in. × 24 in. × 12 in. high, and the rating is 65 kW.

These furnaces have several interesting design features, particularly with reference to the heating elements, which are the subject of patent application, quenching arrangement, and accessibility of components for maintenance purposes. In addition, the system of control is such that automatic governing of the treatment cycle is obtainable. The electric radiant tube element is based on the well-tried tubular design, which provides the minimum of interference with the element's capacity to radiate to the furnace chamber via the outer sheath. Upon quenching the work from these furnaces, an auxiliary pump is brought into action to bring about an extra-vigorous circulation of the quenchant, at the same time the quenching platform oscillates in the vertical plane.

In our last survey reference was made to the Tricarb technique, and to the fact that the furnace applying it can be used interchangeably for homogeneous carburising, controlled case carburising, carbon restoration, hardening, or carbonitriding. Heating chamber, protective atmosphere vestibule, and quench tank are combined into one compact unit. During heating and before quenching, both temperature and carbon potential of the atmosphere are automatically measured and controlled directly from the heating chamber. At the elevated temperatures normally used in its heat treatment, steel is very sensitive to the carbon potential of

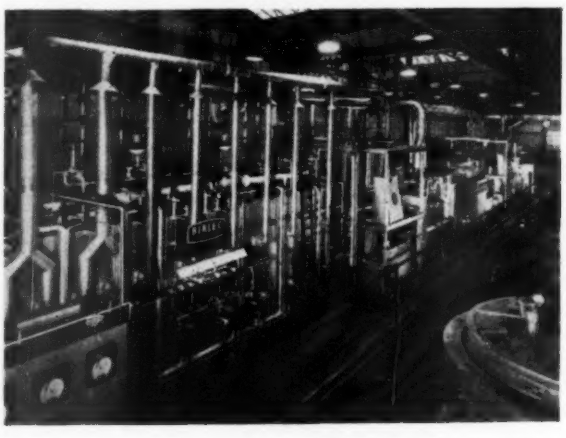


Courtesy of Integra, Leeds and Northrup, Ltd.

Fig. 24.—Sketch of a disassembled Carbohm unit used to control the carbon potential of the carburising atmosphere.

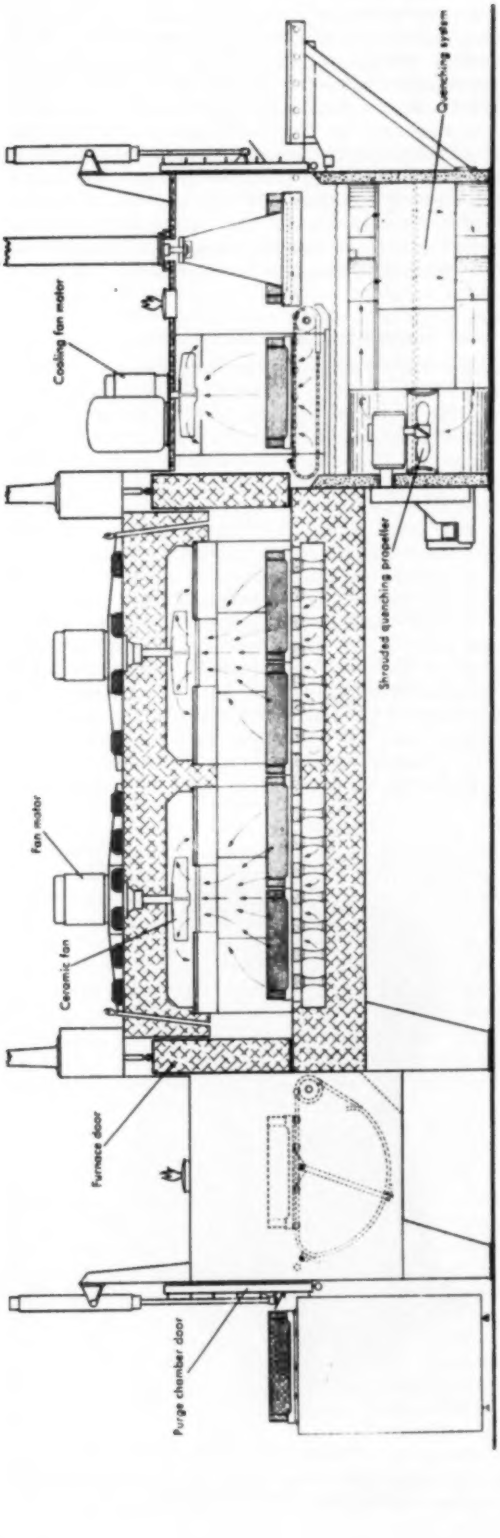
the atmosphere surrounding it. The carbon potential is dependent not only on the composition of the gas but also on surrounding conditions, such as temperature, condition and area of work surface, furnace condition, catalytic agents and contaminants. In treatments such as hardening, the atmosphere surrounding the work should be protective and of a carbon potential which equals that of the steel, but where carbon is to be added to the steel, as in carburising or carbon restoration, the surface carbon is frequently required to be held to a definite value. This is necessary to produce the optimum metallurgical properties desired. After careful study and investigation a primary element has been developed which is as fundamental to the measurement of carbon potential as is the thermocouple to the measurement of temperature. This element is known as the Carbohm unit, and a drawing of it is shown in Fig. 24. It may be used to measure and control carbonaceous atmospheres, and means have been developed to permit repeated use at the high temperatures required for ferrous metal treating. There has also been developed a method of self calibration which is a practical necessity, since there is no other measuring device available for comparison purposes. A carburising furnace, built by Integra, Leeds and Northrup, Ltd., is in commission which incorporates the Carbohm element.

The continuous gas carburising furnace shown in



Courtesy of AEI-Birlec, Ltd.

Fig. 25.—General view of a triple track pusher furnace for gas carburising bearing ring components.



Courtesy of Ipsen Industries, Inc.

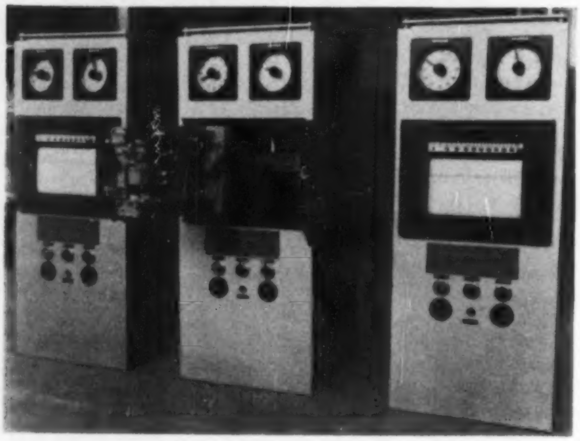
Fig. 26.—Showing the general design of a new range of pusher furnaces of the sealed quench type.

Fig. 25 is part of the new plant installed by British Timken, for the treatment of bearing cups and cones which progress through the furnace on trays actuated by hydraulic pusher mechanism. The furnace is heated by gas-fired radiant tubes arranged in four zones, each under independent and automatic temperature control. Three tracks are operative and the total cycle time in the furnace heating chamber is 24 hours. At present, identical time cycles operate on the three tracks, but appropriate sequence equipment has been incorporated to enable different time cycles to be used on individual tracks. The heating chamber is 31 ft. 6 in. long and has a cross section measuring 6 ft. 4 in. wide × 1 ft. 6 in. high. Safety features have been provided against the possibility of power failure, in which case the inner and outer furnace doors rise automatically, and the furnace is shut down. After automatic oil quenching and discharge, the work trays pass through a washing station comprising two compartments, one for spray wash and the other for a hot water rinse. The trays are propelled through the washing station by a motor-driven chain conveyor.

A new range of pusher furnaces has been introduced by Ipsen Industries, Inc. These are automated, high output, heat treating furnaces which will provide continuous production heat treating for comparatively modest throughputs from even more modest floor areas, and should fill a gap between large multi-track continuous furnaces and the necessarily smaller sealed quench units. These furnaces are not confined to carburising or carbonitriding, but may be used for clean hardening, sintering, normalising, annealing and brazing, as they have a maximum temperature of 1,100° C. As will be noted in the drawing, Fig. 26, they comprise a purge chamber, multi-zone furnace, combined forced atmosphere cooling chamber, and insulated controlled temperature oil quench tank; the features of earlier models are allied to new features to ensure constant production and the highest quality of output.

The heating chamber is divided into two, three or four zones; each zone holds two trays and has its own temperature control and circulating fan; the zones are separated by arches. Work is pushed through the furnace in alloy trays resting completely on the silicon carbide hearth. Demountable silicon carbide baffles and connecting arch, arranged to ensure an even distribution of heat, completely shield the work load from the radiation from the heating tubes, and promote full convection heating of the work. Heating is accomplished by means of super alloyed ceramic heating tubes, which are impervious to high carbon and high hydrogen atmospheres, as well as being resistant to the normal changes involved in heating and cooling. These tubes allow for continuous operation, and each is vertically mounted and sealed with a silicone ring. A premix type burner fires upwards to ensure complete combustion within the heated portion of the tube, and coupled with the use of patented "flamebusters" has improved heating efficiency over older models. Electric resistance heating is equally available—the elements are readily accessible in the same ceramic radiant tubes as used for gas firing.

A smaller multi-purpose closed quench furnace installed at Allen West and Co., Ltd., has loading dimensions 12 in. wide × 24 in. deep × 10 in. high. In this case the furnace chamber is heated by Corrtherm



Courtesy of British Furnaces, Ltd

Fig. 27.—Instruments used in the Autocarb system for recording and controlling the dew point of gas atmospheres.

elements, which are corrugated sheets of nickel-chromium, covering practically the entire walls of the chamber. These elements have the advantage that they are unaffected by carburising gases, their operating voltage being so low that leakage through carbon deposition is impossible. The furnace incorporates a large capacity oil tank with electrically driven agitator and oil temperature control, a water-jacketed slow cooling chamber, a purging chamber, and a double-deck charge elevator. The installation, complete with a 250 cu. ft./hr. endothermic atmosphere generator and fully automatic temperature control gear, is of Electric Resistance Furnace Co., design and manufacture.

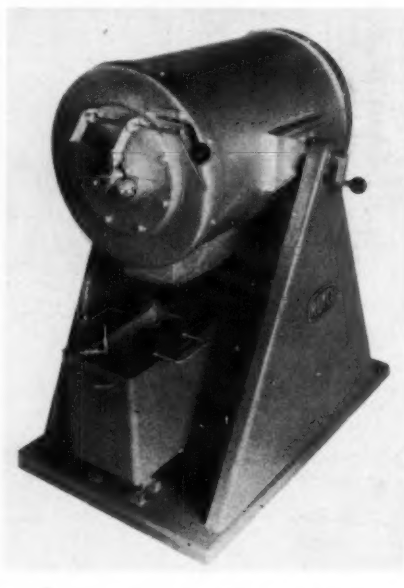
Of advanced design is the continuous gas carburising plant installed by the Incandescent Heat Co., Ltd., at the works of a French automobile company for the treatment of transmission components conveyed through the installation on jigs and trays. It comprises a single track pusher type carburising furnace heated by gas-fired radiant Jetubes, the gas-tight casing having fans for circulation and sealing canopies at each end. After carburising, the trays of work are quenched one at a time via the vestibule at the discharge end of the furnace into a mechanised hot oil quench tank. The components are then conveyed through a degreasing and rinsing machine and a tempering furnace.

In some cases, before undertaking large scale production, the expedient is adopted of installing a small pilot plant in order to collect data. Wild-Barfield Electric Furnaces, Ltd., for instance, have a pilot plant, designed basically on one of their standard carburising furnaces, but supplied with an atmosphere control panel, which enables gas carburising, carbonitriding or straight hardening to be carried out in conditions simulating those obtaining during actual production. This installation is provided with a hot oil quench tank operating at 140°–180° C. for the purpose of reducing distortion of parts heat treated.

Adjusting the flow of air or enriching hydrocarbon to the furnace or generator, in direct response to the dew point of the atmosphere, is obtained by means of control systems, which maintain specified conditions automatically. The Autocarb system supplied by British Furnaces, Ltd., and shown in Fig. 27, is simple and comprises compact units which indicate, record and control the dew points of gas atmospheres in continuous and batch furnaces and atmosphere generators: they control dew points within $\pm 2°$ F. On continuous furnaces, separate zones of atmosphere control can be established and automatically maintained. If manual control is preferred, the Autocarb system will maintain the desired potential for each temperature established in the heating chamber. On endothermic gas generators, Autocarb systems automatically and continuously compensate for fluctuations in the composition of the reaction fuel gas supply and the humidity of the reaction air. This maintains the dew point of the product gas constant.

Hardening and Tempering

Although many multi-purpose furnaces are used for hardening components, furnaces are also designed especially for a particular form of heat treatment and they vary considerably in capacity from the very small batch type to the large continuous furnace. The hardening of very small and delicate parts can present handling difficulties and to overcome these a rotary tube furnace has been introduced which tilts on a floor standing framework (Fig. 28). The tilting of the furnace forward simplifies the charging, and when it is tilted backwards the heated parts are immediately transferred to the quench tank. The furnace operates in the horizontal position, its cylindrical charge retort rotating at a speed of 10 r.p.m. The furnace retort is a solid-drawn heat-resisting steel tube, with the charging end cut at an angle of 45° and covered with a flap door. At the opposite end the tube has an atmosphere inlet fronted by a barrier of heat resisting steel gauze. The retort is heated by an outer refractory tube, wound with



Courtesy of Royce Electric Furnaces, Ltd.

Fig. 28.—A rotary tube furnace for the hardening of very small and delicate parts.

nickel-chromium wire and backed by refractory brick and insulating brickwork. The furnace has a cylindrical steel casing with a terminal box on the underside. Fitted on the framework under the furnace is a quench tank with oil inlet, overflow and drain. The furnace illustrated has an inner diameter of 2 in. and a heated length of 12 in. It is rated at 1·5 kW. and provides for temperatures up to 900° C.

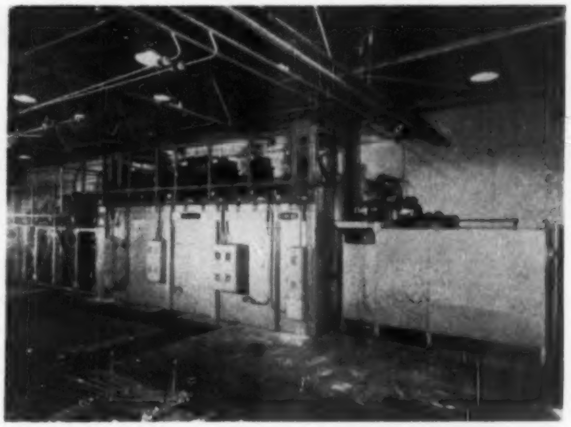
The efficacy of continuous or semi-continuous furnaces for production heat treatment needs no amplification. In a Wild-Barfield installation of shaker hearth furnaces for the hardening and tempering of a miscellany of springs and spring clips on a continuous basis, each pair of hardening and tempering equipments is installed so that the discharge end of the former is adjacent to the entry end of the latter in order to reduce handling. Hardened work is removed from the quench in catch baskets and allowed to drain prior to being placed in a centrifuge to remove all surplus quenchant. It is then loaded into the tempering furnace. The output of each unit is 200 lb./hr. and the ratings are 30 and 18 kW. for the hardening and tempering units, respectively.

The continuous line installation recently commissioned at British Timken for the treatment of bearing rings, cups and cones, has a Birlec roller hearth furnace for hardening, to which bearing ring components are transferred after sub-critical annealing in the pusher furnace. The heating chamber of this hardening furnace, which measures 18 ft. in length, is electrically heated by tape elements in the roof and by cast grids in the hearth. There are two zones in the furnace, with a total rating of 120 kW., and each component completes the hardening cycle in approximately 1 hour. The rollers forming the hearth of the furnace are arranged in a number of sections, each individually driven from a main shaft running longitudinally at the side of the furnace, just above floor level. At the discharge end of the furnace, the last section of rollers is fitted with an overdrive for fast discharge. Two photo-cell units control the operation of the fast roller drive gear and the discharge door.

The final stage of the heat treatment operation is carried out in a continuous slat conveyor tempering furnace, rated at 48 kW. The furnace chamber, 15 ft. in length, is heated by special electric elements fitted in the side walls and arranged in two zones. Work trays travel through the furnace on a series of steel slats supported by roller chains which engage sprockets at the ends of the frame. To promote convection heating, the slats are perforated and a vigorous air flow through the load is maintained by four roof-mounted fans.

An interesting unit recently installed at the Royal Ordnance Factory, Fazakerley, is a fully automatic continuous hardening and tempering furnace for the treatment of carbine barrel forgings (Fig. 29). The complete installation comprises one pusher type hardening furnace with an automatic quench and degreasing unit, together with a pusher type tempering furnace, which is also equipped with a quenching and degreasing unit. A protective atmosphere unit is employed with the hardening furnace. The hardening furnace has a rating of 120 kW. in two independent automatically controlled zones. The maximum temperature is 900° C., the normal operating temperature being 850° C. The tempering furnace has a rating of 90 kW. in three independent zones, and temperatures up to 650° C. are employed.

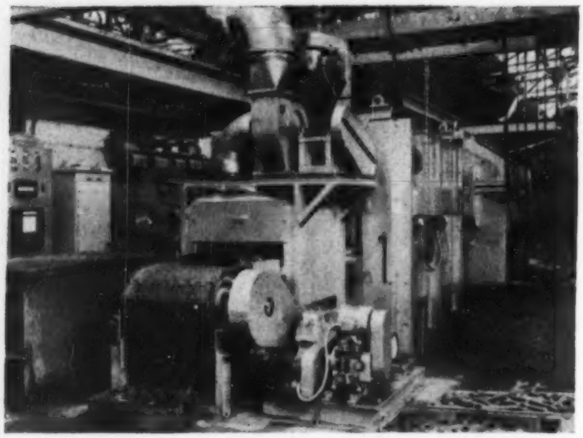
The hardening and tempering lines are arranged side by side, and linked at either end by cross traversing conveyors. Barrels are suspended from specially constructed heat resisting jigs, each capable of carrying eight forgings, and loading and unloading are effected whilst the carriers are on the final cross traversing track conveyor. Forgings to be treated are conveyed automatically on to the pivot head of the hardening furnace hydraulic pusher, which conveys the carriers separately into the hardening furnace. Two rows of heat resisting skid rails support the charge carriers during their passage through the furnace. As the pusher propels the carriers through the furnace an extractor gear is timed to remove the carrier from the furnace chamber on to the platform of a quenching hoist. Immediately the extractor gear has removed a charge carrier from the furnace and deposited it on the quench hoist platform, the platform automatically lowers and places the carrier on to the quench conveyor. This conveys the charge through the quenching medium, and also through the degreasing unit. Further extractor gear removes the charge carrier from the quench conveyor and transfers it on to a traversing conveyor. By this arrangement, the charge carriers are conveyed into the tempering furnace line. The method of conveyance through the tempering furnace line is roughly the same as that used for the hardening furnace.



Courtesy of G.W.B. Furnaces, Ltd.

Fig. 29.—Overall front view of hardening and tempering pusher furnaces for the treatment of carbine barrel forgings.

Another in-line installation for hardening and tempering is shown in Fig. 30. It is designed for the heat treatment of small tools, using cast link conveyors, and comprises a hardening furnace, a duplex oil/water quench, and a tempering furnace. The hardening furnace is rated at 90 kW. and is designed for a maximum temperature of 1,000° C., the normal working temperature being 900° C. Heating elements are located in the hearth, side walls and roof, and there are two separately controlled zones. Output is 2½ cwt. of hardened small tools per hour. The tempering furnace is designed somewhat similarly to the hardening furnace; it is rated at 50 kW. for a maximum temperature of 700° C., the working temperature being 550° C. An air circulating fan in the roof gives temperature uniformity throughout the furnace. A special cooling hood at the discharge end reduces the temperature of the work by drawing cold air over it, the air being exhausted through the top of the canopy.



Courtesy of Metalectric Furnaces, Ltd.

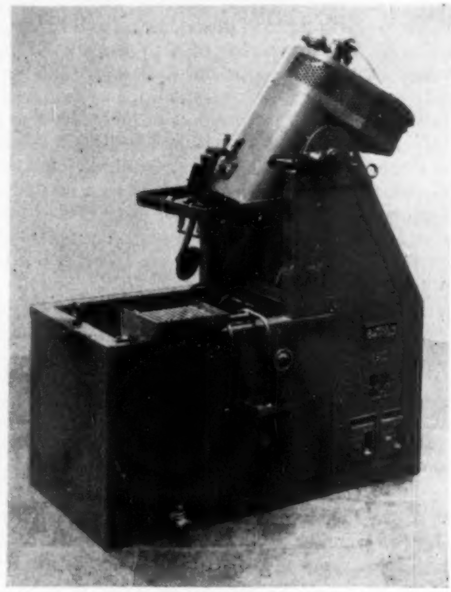
Fig. 30.—An in-line installation for hardening and tempering, designed for small tools.

Three furnaces have recently been installed, each of which takes charges of steel castings up to 25 tons. Built by the Electric Resistance Furnace Co., Ltd., they are elevator furnaces of rectangular design mounted above floor level and arranged for bottom loading: they are arranged in line with large oil and water quench tanks for easy operation. Charges are inserted on bogie hearths which are raised and lowered by hydraulic cylinders. The furnaces are of identical size and can take any of the bogies, all of which have hearths 16 ft. long × 9 ft. wide. The bogies run on rails beneath the furnaces and charges can be given a range of heat treatments without restacking for each process, which may cover annealing, stress relieving, hardening and tempering. The charges can be moved quickly from a furnace to a selected quench. Two of the furnaces can operate at 1,300° C., whilst the other has a maximum operating temperature of 800° C. Forced air circulation is used to ensure temperature uniformity when operating below 800° C. These furnaces are specially designed to have reduced heat storage capacity and to give high rates of heating.

Although the production of a range of standard furnaces is an ideal to be aimed at, occasions arise where special equipment is needed. The small rotating and tilting unit for heat treating small components seen in Fig. 31 is a typical example. The rotation is effected by a suitable electric motor, and tilting by hand. As may be seen, the chamber can be locked at any one of three angles, the illustration showing the quenching position. The built-in quench tank is provided with heating elements and the quenchant temperature is thermostatically controlled: cooling tubes are incorporated.

Silicon carbide heating elements extend through the back wall into the heating chamber in a new series of compact self-contained units designed for operating at temperatures up to 1,400° C. (Fig. 32), and permit direct operation on mains voltages. Furnaces can also be supplied on suitable stands which incorporate a controlling pyrometer and a step-down transformer with tappings to compensate for element ageing. The vertical sliding door is counterbalanced for easy operation and the generous thickness of high quality insulation, coupled with careful design, ensures low heat losses coupled with excellent temperature uniformity.

New designs of horizontal gas fired batch furnaces for operation in the temperature range 400°–800° C. and 700°–1,200° C., incorporate Barlow-Whitney's latest type air blast tunnel burners in a special arrangement utilising the principles of jet re-circulation, which takes advantage of the high velocity of the combustion gases and ensures excellent temperature uniformity throughout



Courtesy of Wild-Barfield Electric Furnaces, Ltd.

Fig. 31.—Special tilting rotary furnace with hot oil quench.

the furnace chamber and rapid heat transfer to the charge.

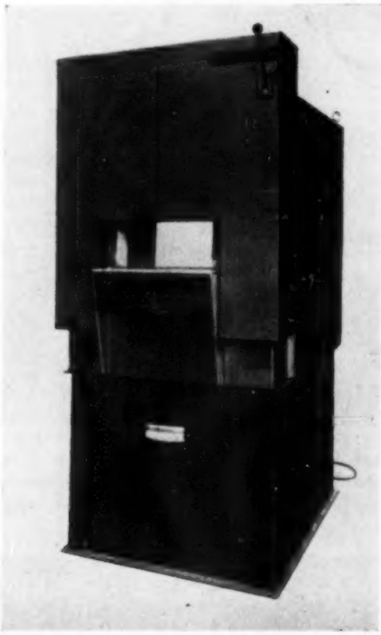
An unusually large and interesting end-flow furnace for precipitation and solution treatment of aluminium has been installed by AEI-Birlec, Ltd., at the Birmingham works of James Booth and Co., Ltd. This furnace, which is rated at 575 kW., has a total length exceeding 70 ft. and accepts charges of light alloy plates and sections loaded on skips 52 ft. long. High speed air circulation is achieved by a twin-fan assembly mounted at the end of the furnace remote from the charging door. Mild steel baffles and deflector plates are used to promote uniform flow. An important feature of this installation is the twin-track charging machine which is arranged to run transversely on rails across the mouth of the furnace. Skips are charged into the furnace at a rate of 20 ft./min. Heavy loads are discharged at the same rate after precipitation treatment, but lighter loads can be rapidly discharged at 200 ft./min. to permit quick quenching for solution treatment.

Salt Bath Heating

To meet the increasing interest in isothermal methods of heat treatment the "Cassel" Ajax Electric T.I.Q. furnace, shown in Fig. 33, has been designed specifically for quenching steel parts during austempering or martempering treatments. The main feature of this furnace is the "cataract" quenching arrangement for circulating the salt past the work at speeds that can be closely

controlled. This enables results to be obtained that were not thought possible in salt, and a wider range of steels can therefore be treated. It is claimed that the furnace will do anything that can be tackled in agitated oil, the range of quenching temperature being considerably greater, while the fire hazard inherent in hot-oil quenching is eliminated.

The salt is brought to operating temperature by immersion heaters and, during quenching, air is circulated between the pot and the casing wall to dissipate heat arising from quenching. Circulation of the molten salt is concentrated in the quenching chamber by a cylindrical header, connected at the bottom to a variable speed pump. The salt flowing through the " header " extracts heat from the work with remarkable efficiency. In most cases the salt is made to flow downwards through the chamber, but the pump can be reversed so that the salt flows upwards through the " header " at high velocities—without splashing. If necessary the " header " can be removed in a few seconds to give more general agitation in the quenching bath. This salt

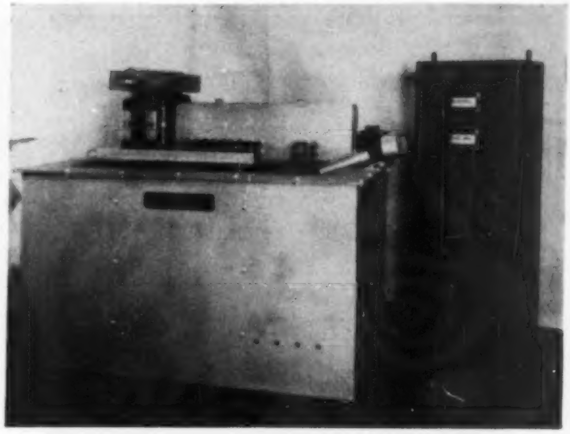


Courtesy of Barlow-Whitney, Ltd.

Fig. 32.—Series E-SCF 1400 furnace for use at temperatures up to 1,400° C. in the tool room and laboratory.

furnace also incorporates a salt separation system designed to reduce the concentration of high temperature salt carried into the bath from an austenitising bath. Separation takes place in a second chamber through which the quenching salt circulates automatically. High temperature salt settles out and is removed by dredging. A lesser known feature of salt bath quenching is that water can be added to the molten salt to increase the quenching power (the preferred water content is approximately 1%). This has been done successfully and without danger at temperatures up to 300° C. by means of a simple injector device.

The salt bath illustrated in Fig. 34 is one of the latest Brayshaw designs, intended for operation at temperatures



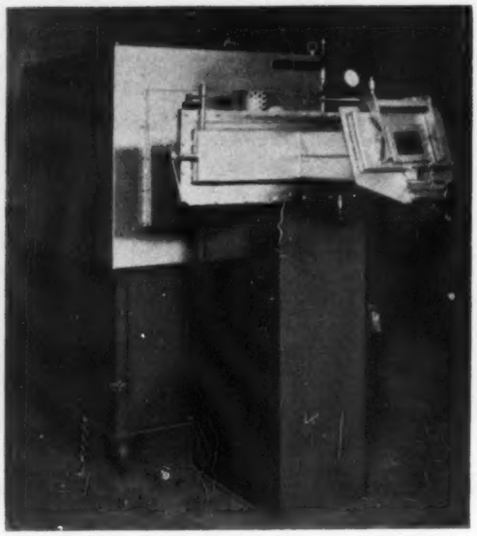
Courtesy of Imperial Chemical Industries, Ltd.

Fig. 33.—The " Cassel " Ajax electrically heated salt bath furnace designed for quenching steel parts during austempering or martempering treatments.

up to 875°–900° C. and fitted with a pressed mild steel pot calorized internally and externally. Where temperatures up to 1,000° C. are required, a heat resisting pot is recommended. The furnace is available as an open top bath or it may be fitted with such extras as a hood ; a fan to draw the fumes from the top of the bath into the flue system ; refractory lined split covers ; and a direct swing jib crane complete with work basket. Heating is effected by single nozzle mixing burners of the diffusion type, designed to provide gas layer protection for the pot. The burners fire tangentially and towards the top of the pot, thus ensuring that melting commences at the top : they are designed to consume town's gas at 2–3 in. W.G. in conjunction fan-blown air at 10 in. W.G.

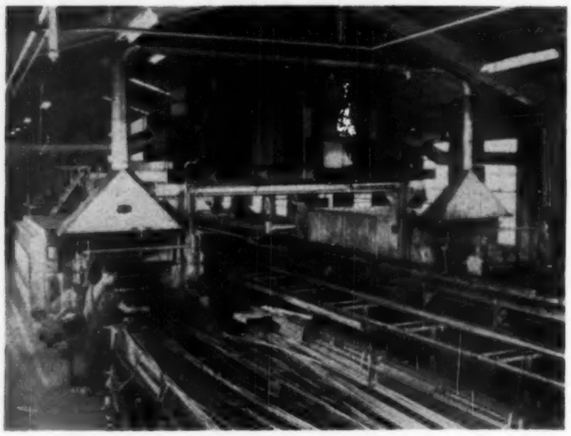
Courtesy of Brayshaw Furnaces, Ltd.

Fig. 34.—Liquid bath furnace for use with salt, cyanide or lead.



Courtesy of Barlow and Whitney, Ltd.

Fig. 35.—A horizontal muffle furnace unit for scale-free high temperature copper brazing.



Courtesy of Electric Furnace Co., Ltd.

Fig. 36.—An installation of continuous copper brazing furnaces.

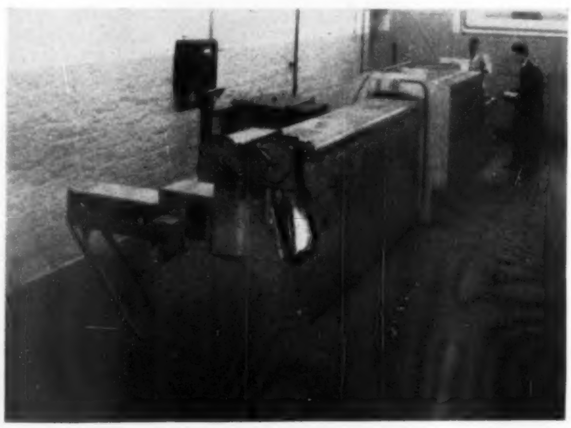
In a process which depends very much upon the bath being free from metallic oxides, the use of graphite electrodes is an obvious advantage. Thus, Efco-Upton salt baths, with continuing graphite electrodes, have been supplied for brazing aluminium. As the electrodes are consumed in the bath they are pushed further in by means of a screw mechanism, and when an electrode is nearly finished a new one is screwed into its external end; this overcomes the usual objection to using consumable electrodes, i.e., the need to unbrick a bath to fit new electrodes before the lining has served its full life.

Brazing

Considerable progress is being made in the application of furnaces for brazing, and some of the furnaces already mentioned can be used for this purpose. Many furnaces are, however, specially designed for brazing, and typical of these is the horizontal muffle furnace unit for scale-free high temperature copper brazing of stainless steel components shown in Fig. 35. The process calls for close temperature uniformity in a hydrogen atmosphere with a low dew point to ensure really satisfactory results, the charge container being provided with an internal hinged screen to separate the heated section from the water-cooled lock chamber, which has an inner gas-tight sliding door. Both screen and inner door are externally operated and a pusher mechanism enables the charge to be loaded and unloaded via the lock-chamber, and retained in the hydrogen atmosphere until the temperature is sufficiently low for safe handling in air without risk of oxidation occurring. A further feature of this unit is the mounting of the furnace chamber on wheels, permitting its withdrawal from the charge container, which is fixed on a stand housing a temperature recorder. This arrangement speeds up cooling and eliminates the risk of displacing delicate component assemblies being brazed, which might otherwise occur.

An installation of continuous copper brazing furnaces is shown in Fig. 36. On the left is a 31-tube furnace, rated at 200 kW. and operating at 1,150° C. The 100 ft. tubes to be brazed pass through heating and cooling pipes where they are surrounded by a protective atmosphere. Atmosphere and temperature control equipment are mounted on a platform above the furnace.

Fig. 37 shows a pusher type furnace used for the brazing of chuck components. The equipment comprises an entry duct, heating chamber and cooling plant, the entry and exit being fitted with flap doors; gas curtains are provided. The heating chamber has high temperature elements of the non-metallic type, fed at low voltage from a tapped transformer. A protective atmosphere is supplied by an ammonia cracker, and work to be brazed is placed in heat resisting trays, which are progressed through the chamber by a power-operated pusher mechanism. Interlocks are incorporated to ensure that the pusher will not operate if a tray is inserted incorrectly, if the entry door is open, or if there is a tray in position at the unloading end. This equip-

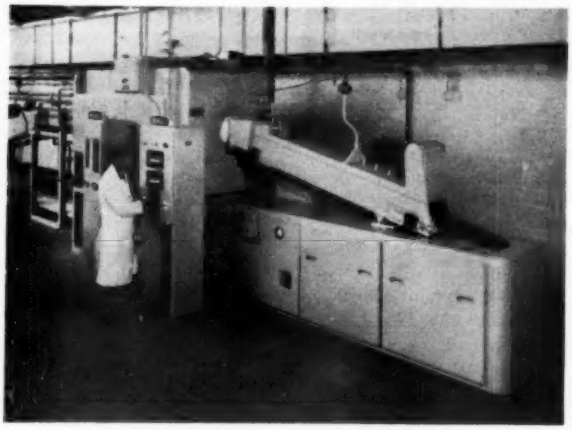


Courtesy of Wild-Barfield Electric Furnaces, Ltd.

Fig. 37.—A special pusher brazing furnace for copper brazing chuck components.

ment was designed for an output of approximately 200 lb./hr. and a maximum operating temperature of the order of 1,150° C.

A compact installation for brazing is in commission at an important Indian cycle works. Of Incandescent design, it is a mattress conveyor furnace heated by Jetube heating elements, fired by gas-oil. Each Jetube has its own oil and gas regulating control valves. The heating chamber has a removable top section for access to brickwork and conveyor, the latter, in the heating section, being carried on cast heat-resisting hearth plates with cored holes to allow radiation from the Jetubes below. The water-jacketed cooling chamber is in two longitudinal sections, and has the usual arrangement for expansion. Overall length of this plant is 61 ft. 9 in., the heating section being 6 ft. 2 in. long and the mattress conveyor 1 ft. 3 in. wide. The furnace has an output of 1,200 brazed handlebars per eight-hour shift, at a temperature of 980° C. Atmosphere is provided by an electrically heated ammonia dissociator, with refrigerator and activated alumina dryer, giving a final dew-point of −30° F.



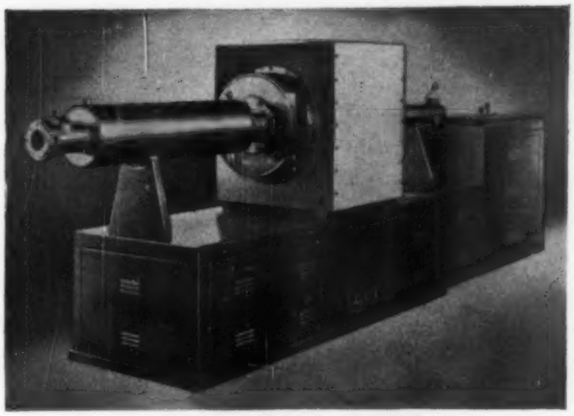
Courtesy of A.E.I. (Birlec), Ltd.

Fig. 38.—Valve components are heat treated in this 40 kW. hump-back mesh belt conveyor furnace.

The versatility of mesh belt furnaces of the "hump-back" type is well illustrated by a recent installation at the Electronic Apparatus Division, Lincoln, of Associated Electrical Industries, Ltd. (Fig. 38). The furnace is used in the manufacture of valve components; for copper brazing mild steel components in a hydrogen atmosphere; and for glass to metal sealing in air. Globar elements arranged in two zones heat the furnace chamber, and the total rating is 40 kW. A hump-back furnace was specified for this application to conserve supplies of the hydrogen used as a protective atmosphere within the furnace chamber. A fault protection system has been incorporated as a safety precaution in view of the explosion risks associated with the use of hydrogen.

Sintering

Several new furnaces have been designed for sintering. An interesting example is that shown in Fig. 39, for the sintering of tool tips: it provides for temperatures up to 3,000° C. The furnace casing, of welded steel plate, houses a carbon tube which is surrounded by high grade refractory and heat insulation and is supported at each end by heavy water-cooled castings of a copper-chromium alloy having high thermal and electrical conductivity. The tube is 3 ft. 6 in. long, has an inner diameter of 5 in. and a wall thickness of 1 in. The furnace tube is fitted with preheating and cooling sections, both being solid-drawn steel tubes fitted with an entrance or exit door. The cooling section is fitted with a water jacket and has an inspection window of quartz glass in its hinged door. Entries are provided for a protective atmosphere and gas screens are fitted at each door. The carbon tube is connected to the low voltage output of a step-down transformer, voltage variations being made with a transductor. Charges are progressed through the furnace with electrically operated pusher mechanism giving speeds as low as 1 in./min. This furnace is rated at 150 kW. and has overall dimensions 18 ft. 6 in. long × 3 ft. 2 in. wide × 5 ft. 9 in. high.



Courtesy of Royce Electric Furnaces, Ltd.

Fig. 39.—Furnace designed for the sintering of hard tool tips.

Resistance heated vacuum furnaces are frequently employed for sintering operations, and Wild-Barfield have supplied seven for sintering uranium dioxide pellets for fuel elements. The heating element is molybdenum, as also is the charge carrier that carries 2,500 pellets, each $\frac{3}{8}$ in. diameter × $\frac{3}{8}$ in. high. The furnace is rated at 60 kW., and is fitted with a potentiometric programming and recording controller. For a full charge, the total cycle time is 14 hours, made up of 4 hours, 3 hours and 7 hours for attaining 1,650° C., holding at temperature, and cooling, respectively.

Vacuum Metallurgical Developments, Ltd. have under construction a furnace for sintering tantalum capacitor bodies. The furnace is of the vacuum type and it was originally intended to use R.F. induction heating, but this idea was abandoned in favour of resistance heating. The main advantages are: (*a*) operation at about 10 V. prevents arcing between the bodies; (*b*) by making the hot zone long enough the internal radiation shields are heated, so that more uniform temperature is obtained; (*c*) the cost of the equipment is much less than for R.F. heating. The heating element, radiation shields, and tray assembly, are all made of tantalum, so that contamination of the bodies is avoided. The charge is lowered into the heating element, which is in the form of a tube, on a special tray assembly. Rapid heating brings the charge up to 2,000° C., and the wax driven out

Courtesy of Sintering and Brazing Furnaces, Ltd.

Fig. 40.—An 18 in. wide three-zone continuous conveyor type sintering furnace.

of the bodies is collected on various baffles and traps. On completion of sintering, a fast cooling rate is achieved by admitting argon into the chamber and recirculating it by means of a fan. One hundred and eighty-five bodies are sintered per cycle.

The three zone continuous conveyor sintering furnace in Fig. 40 is a clean and interesting design which has several uses. Furnaces of this type may have a cast nickel-chrome muffle or be arranged with open silicon carbide hearth plates. A feature of the muffle type is easy access to the muffle via twin opening doors in the top of the furnace case, which facilitates removal of the elements and muffle. The equipment carries fully automatic temperature control and switch gear.

Delapena and Son, Ltd., are now marketing the Balzers type MOV 10 high vacuum sintering furnace which has been developed for processes requiring temperatures up to 1,500° C. and a vacuum of between 1 and 10^{-4} mm. Hg in an oxygen-free atmosphere. Heating is effected by means of a three-phase molybdenum wire element surrounded by a five-ply heat reflector shielding, designed to concentrate and reflect the heat into the chamber with a guaranteed temperature limit within 10° C. Due to the arrangement of the heating element in suspension and the fact that the two inner layers of the heat reflector shield are made from molybdenum sheet, the element is subjected to only very small distortions due to temperature change.

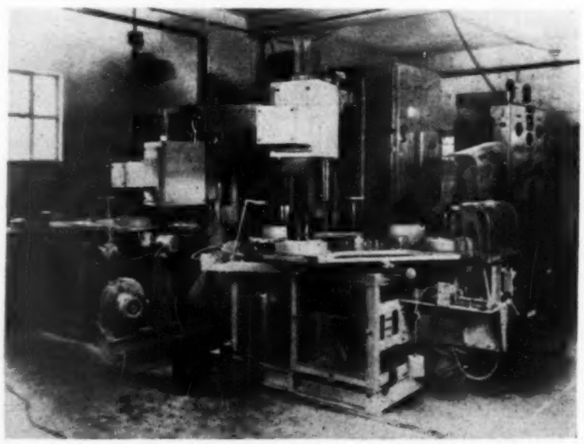
Induction Heating

Progress continues to be made in the application of induction heating and the design of equipment to meet specified conditions and type of work has proceeded at a considerable rate. This method of heating is clean, fast, efficient and flexible, and it is applied not only for reheating but for annealing, case-hardening, hardening, brazing and soldering. Equipment installed at an ordnance factory and shown in Fig. 41 is designed for the rapid heating, prior to shell nosing, of tubular steel forgings 3–4 in. O.D. The equipment comprises two fully automatic indexing turntables designed to accept forgings from the feed conveyor at the rate of 200 per hour. The coils, connected by flexible water cables and busbars and having adjustable raising and lowering mechanisms, heat the workpieces to 1,150° C., after which follow the operations of forging and off-loading. The time cycle, controlled by process timer, allows of a continuous sequence of operations, and the alternate use of both turntables results in steady motor alternator loading. It is a medium frequency (3,000 c./s.) heating equipment, power being obtained from a 150 kW. motor alternator, which is located, with its starter and control gear, in a sub-station.

A unit has been designed by Radio Heaters, Ltd. for surface hardening shafts and similar components up to 12 in. long by traversing them through a single turn inductor. It is intended for use with a 15, 25 or 40 kW. generator, and incorporates a suitable concentrator to match the generator output to a single turn coil. Full quench facilities are provided, including a dwell timer to ensure complete quenching at the end of the work stroke. Water and air supplies and their associated control gear and strainers are mounted outside the cabinet for easy servicing.

Induction hardening equipment has recently been installed at the Edmonton Works of the British Oxygen Co., Ltd. It is at present being used for case hardening a number of shafts and for through hardening a range of bushes, but potential applications are numerous and it is anticipated that the equipment will eventually be used for a much wider range of components. The installation comprises the induction heater, a vertical shaft hardening machine, and a water circulating system. The induction heater is a valve-oscillator type radio-frequency generator, which delivers power at a frequency of 250 kc./s., with a maximum continuous output of 30 kW. A continuously variable output power control is fitted, which can be used for fine matching of the power output to the work over a wide ratio during the heating period. The shaft hardening machine is one of a standard range and is capable of handling shafts up to 48 in. long. Quenching is performed continuously by water sprayed from a quench ring mounted just below the inductor coil. This equipment is shown in Fig. 42.

The R.F. Heating Division of Pye, Ltd., has turned its attention to the induction heating of metals in the course of the last few years, and the latest development, the 6 kW generator illustrated in Fig. 43, is a medium



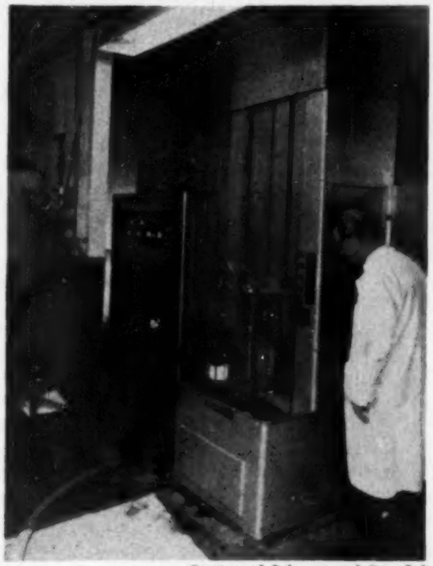
Courtesy of British Geco Engineering Co., Ltd.

Fig. 41.—A medium frequency induction heating equipment for the rapid heating, prior to shell nosing, of tubular steel forgings.

impedance output unit suitable for general purpose heating applications such as annealing, brazing, hard and soft soldering, hardening and tempering. The availability of a high work coil kVA in association with multi-turn coils permits the heating of a wide range of ferrous and non-ferrous loads. The oscillator valve may be either air cooled or water cooled depending upon customer requirements. The controls, indicator lamps, anode current meter and process timer are conveniently grouped on the front panel, and the compact design is such that the floor area is only 25½ × 23½ in. The equipment is self-contained with its own automatic resetting process timer, overload relay to protect the valves, and provision for remote control. The equipment is designed to be operated from a 3-phase supply, 360–440 V., 50 c/s, with a full load consumption of 12·2 kW.

Miscellaneous

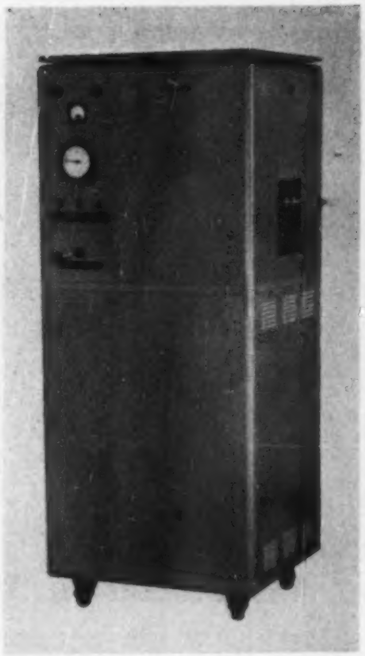
An entirely new range of electric furnaces for the laboratory, workshop and tool room has been introduced by A. Gallenkamp and Co., Ltd., and several of their furnaces have been re-styled. Operating temperatures have been increased and new types introduced which can



Courtesy of Delapena and Son, Ltd.

Fig. 42.—Shaft-hardening and drop-quench equipment, with induction heater, installed by British Oxygen Co., Ltd.

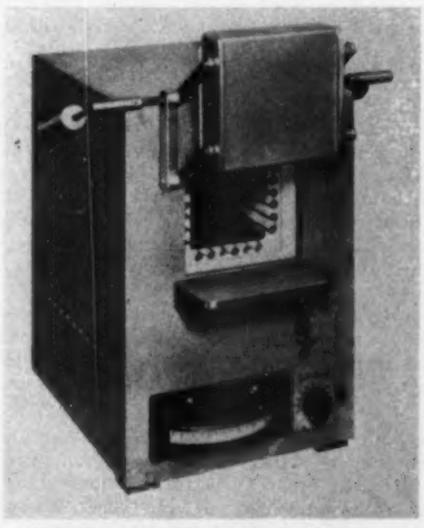
be used at temperatures as high as 1,500° C. Larger sizes are now available and furnaces have, in general, greater useful working spaces due to improved design. The majority of furnaces have built-in controls and pyrometric equipment and are fitted with safety devices which protect the heating elements from accidental overheating. High performance coupled with robust construction and reliability make the furnaces equally suitable for laboratory and industrial applications. Typical of the wide range are the muffle furnace and the box furnace (Fig. 44) both of which are general purpose furnaces, the former designed for a maximum temperature of 1,100° C. and the latter for a maximum of 1,250° C. The muffle furnace, which is available in three sizes, has been completely re-styled and has the option of built-in indicating or controlling pyrometers. The



Courtesy of Pye, Ltd.

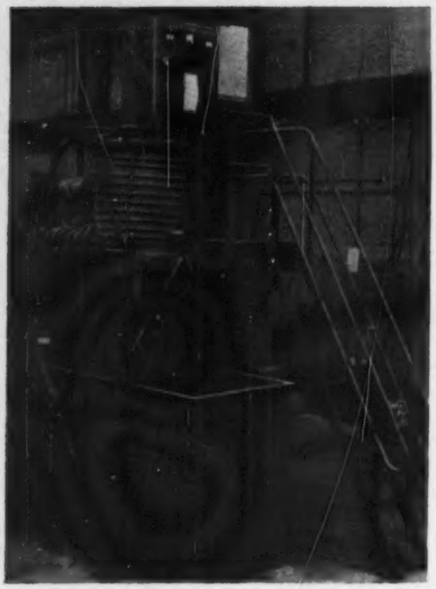
Fig. 43.—6 kW. high-frequency induction generator.

box furnace is new and is built on similar lines to the muffle furnace but heated by heavy gauge internal spiral elements supported by refractory castings, which form a work chamber 6 in. × 6 in. × 12 in. deep. Either manual or automatic control is available. The range includes entirely new furnaces for a maximum working temperature of 1,500° C., and also a range of tube furnaces designed for working temperatures of 1,200°, 1,400° and 1,500° C. respectively.



Courtesy of A. Gallenkamp and Co., Ltd.

Fig. 44.—A new box furnace for general heat treatment operations up to a temperature of 1,250° C.



Courtesy of Vacuum Metallurgical Developments, Ltd.

Fig. 45.—Furnace suitable for water-quenching from high vacuum at temperatures up to 1,250° C.

A range of high temperature "graphite element" furnaces is now being manufactured by Sintering and Brazing Furnaces, Ltd., in conjunction with Spembly, Ltd., of Chatham. Special features of these units include fast rise of temperature—up to 2,600° C. in a maximum of 20 minutes; direct sight of heated work, allowing direct temperature measurement by radiation pyrometer; central uniform temperature zone; and low casing temperature due to efficient insulation and water cooling arrangement. The graphite element profiles can be altered to suit various heating characteristics. All units are supplied for use with an inert operating atmosphere.

In our last survey of heat treatment plant, reference was made to the first of a line of furnaces by Vacuum Metallurgical Developments Ltd., which can be used for water-quenching from high vacuum at temperatures up to 1,250° C. within a few seconds. At that time the work was in the development stage; the quench furnace has since been completed and commissioned and is illustrated in Fig. 45. The components to be processed are contained in a heat resistant basket in a vertical molybdenum resistance furnace. On reaching full temperature argon is let into the furnace chamber, a bottom door opens automatically and the work basket drops through a sealed argon hood into the quench tank. The work is in contact with argon for only a few seconds and high-purity gas is not normally required.

Some heat treatment furnace manufacturers concentrate on standard designs, others, in addition to standard lines, design types to meet individual requirements, while a few, like R. M. Catterson-Smith Ltd. devote the majority of their production to meeting individual requirements for non-standard furnaces, covering temperature ranges from 500° to 1,750° C. for such purposes as preheating, hardening, tempering, sintering, brazing, etc. In such cases designs are prepared following an assessment of the users' production needs. Among those manufacturers concerned mainly with standard designs is Kasenit, Ltd., now occupying new works at Bletchley. This firm has recently exported ten cyanide furnaces and ten high speed oil fired furnaces on Government orders. Two 10 ft. vermiculite furnaces have been despatched to Australia, and more cyanide and high speed furnaces are in hand for Ceylon. Home orders include several oil fired galvanising furnaces, spring heating furnaces and a large number of cyanide furnaces. Particular attention is given to school and college equipment for heat treatment and over a hundred installations have been supplied during the past twelve months.

Hot Scarfing of Slabs

New oxygen-fed hot scarfing machines are to be installed in steelworks near Newport, South Wales, and Ravenscraig in Scotland. The equipment, valued at more than £350,000, will be supplied by British Oxygen Gases, Ltd. Oxygen supplies to operate the new machinery will come from B.O.G tonnage plants now being built under the steelmaking expansion programme.

At the Spencer works near Newport, of Richard Thomas & Baldwins, Ltd., steel-conditioning equipment —the second largest in the United Kingdom—is to go into operation when steelmaking begins towards the end of 1961. Hot scarfing of steel slabs and blooms up to 5 ft. wide and nearly 2 ft. thick is planned with the new machinery, which is capable of conditioning all four faces simultaneously. Alternatively, the equipment can operate on top and bottom faces only, or on edge faces only. Scarfing machinery is also to be installed at the Ravenscraig works of Colvilles, Ltd., near Motherwell. Initially, the equipment will be required to condition only the edges of steel slabs and blooms, and will operate on widths of up to 5 ft. and thicknesses of nearly 2 ft. Provision has been made however, to install a carriage unit which can support the largest machine of this type, for scarfing all faces simultaneously, handling widths of more than 7 ft. and thicknesses of nearly 2 ft.

At both steelworks, the new scarfing machinery will be installed by the steel companies, under B.O.G. advisory supervision. The equipment is manufactured by the Linde department of the Union Carbide International Company, of New York, U.S.A. An agreement is held by B.O.G. to supply this type of equipment in the United Kingdom.

Distington's Latest Foundry Record

A record output of 2,704 tons of ingot moulds, bottom plates, slag ladles and general engineering castings was produced in the iron foundry of Distington Engineering Co., Ltd., during the week ending May 7th. This follows an earlier British and European record for an ingot mould foundry which was set up by Distington in February of this year when over 2,500 tons of finished castings were produced in one week. These continual high outputs are enabling the company to keep pace with the increasing demand from its customers.

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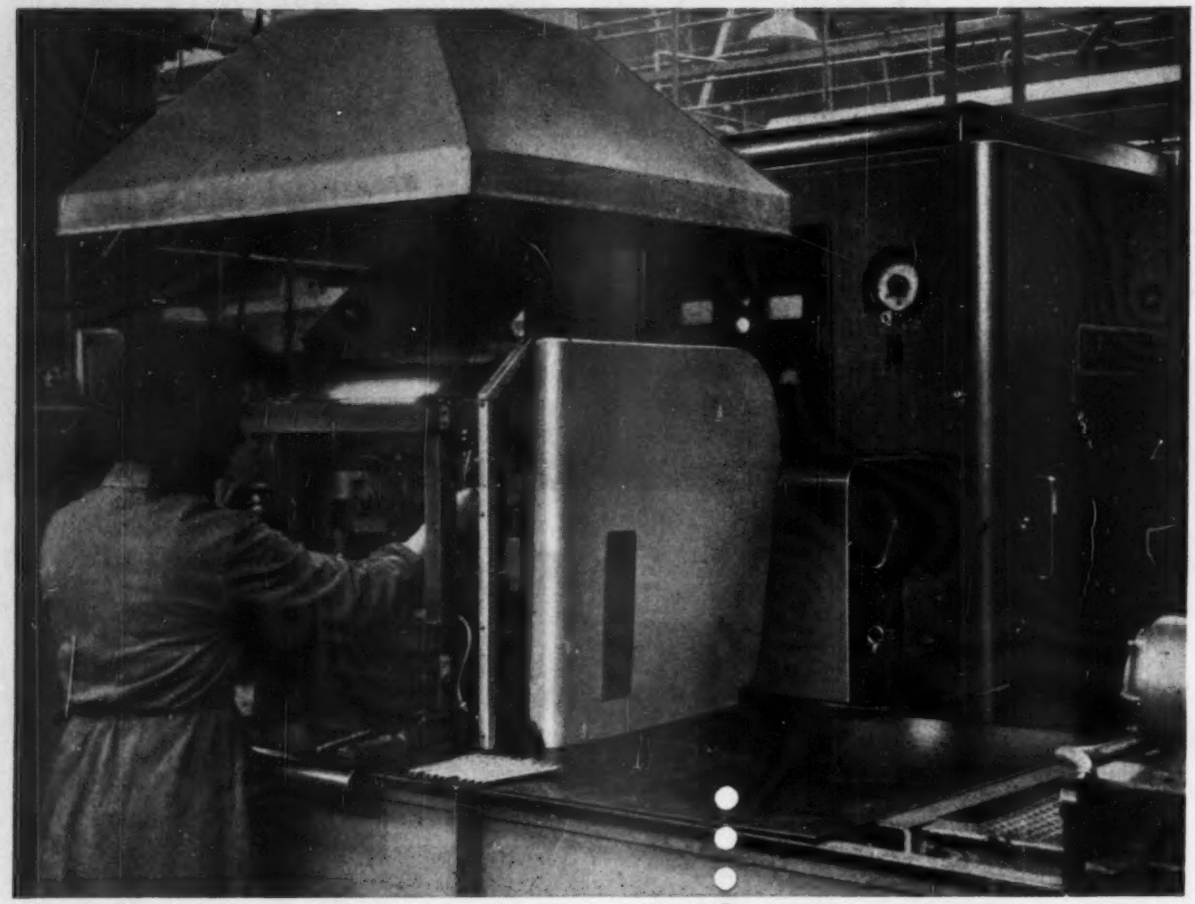

Wild-Barfield A.H.F. equipment is used by Wolf Electric Tools, Ltd., (manufacturers of the well-known Wolfcub drills etc.), for the hardening and tempering of small gears, shafts and pinions. Many other industrial concerns have found that Wild-Barfield A.H.F. induction heating speeds production, saves space and offers savings all along the line. Our engineers will be glad to supply further details and explain how Wild-Barfield A.H.F. equipment can help you.

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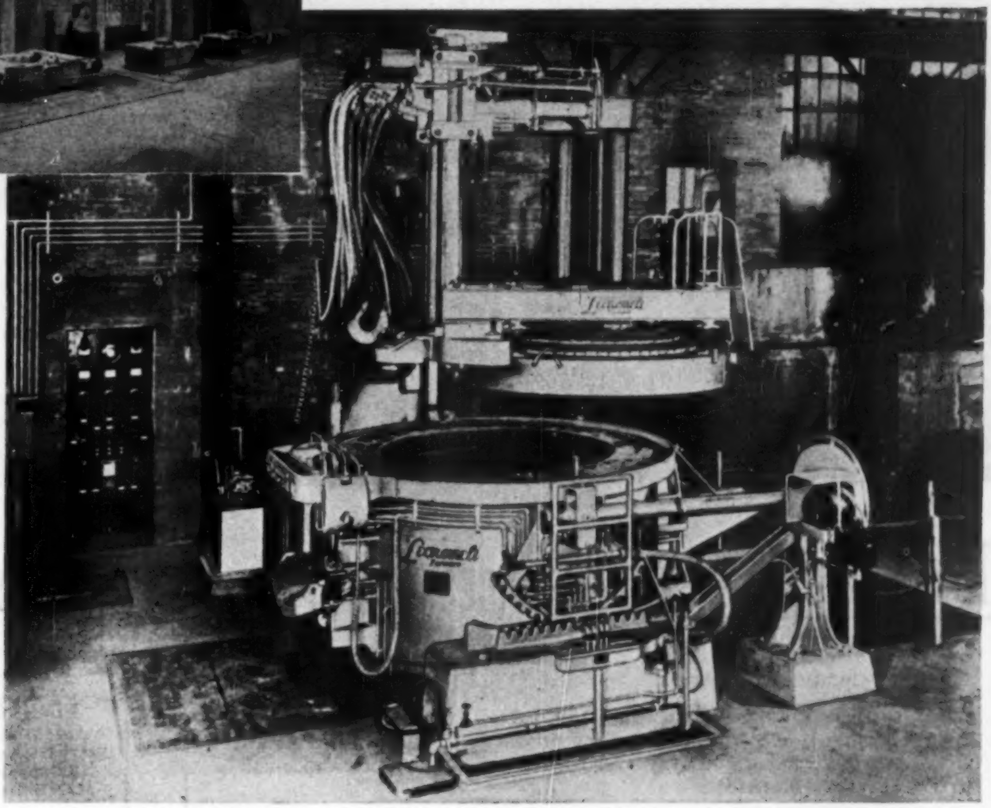
Lectromelt

Demag high-frequency induction furnace installation at a steel making plant, incorporating two 1 ton capacity furnaces, two 660 lb. capacity furnaces, and one 110 lb. capacity furnace.



A 3 ton capacity Lectromelt arc furnace of 9' 0" diameter shown with roof swung ready for charging.

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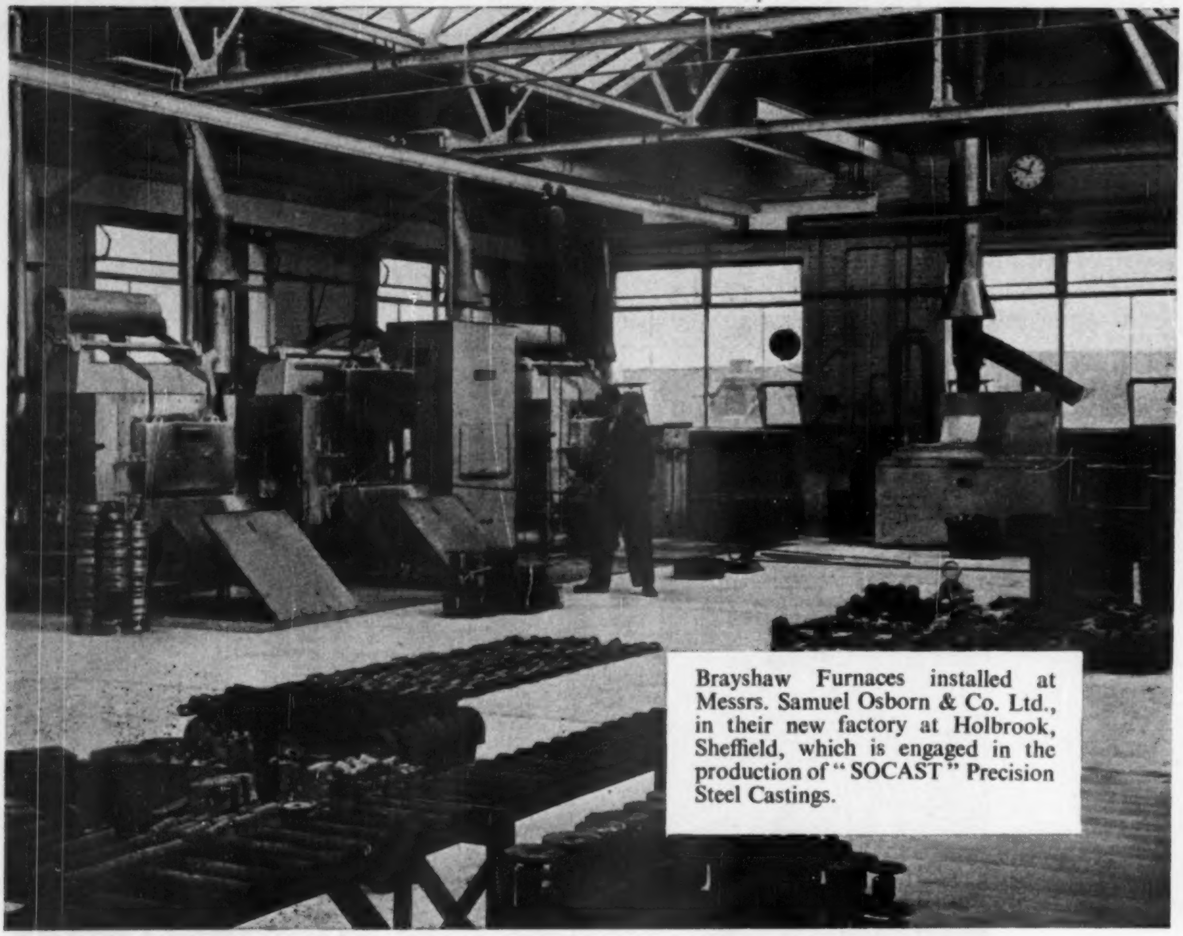

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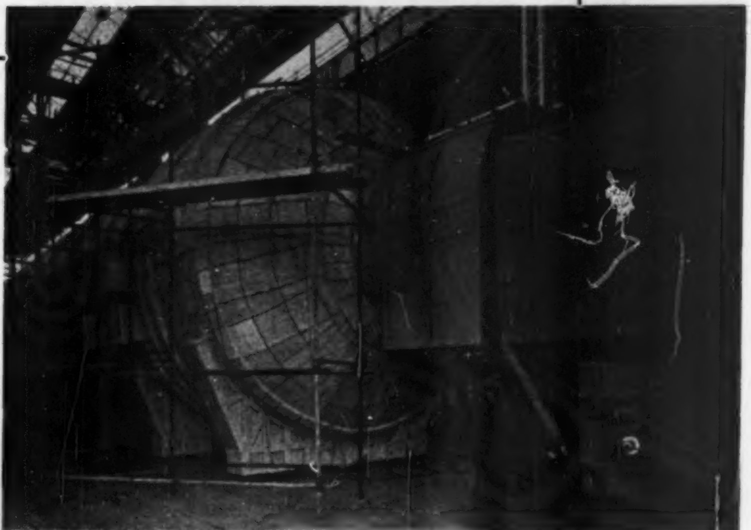
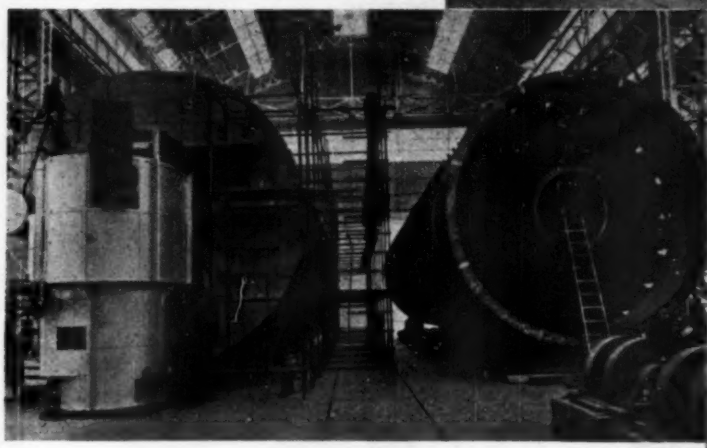
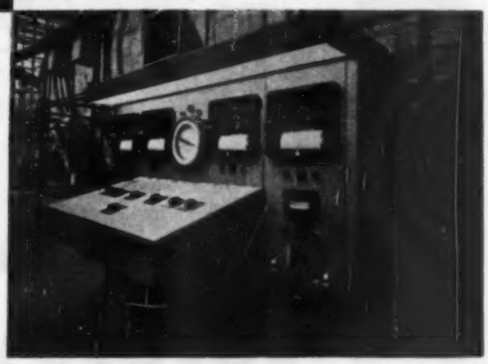


Oil fired convection heating for stress relieving at Nuovo Pignone Company, Massa Carrara, Italy. Heat Exchanger vessels for the Atomic Power Station of Eni-Agip at Borgo Sabotino.



Equipment supplied by Felind Forni Industriali S.R.L Milan (Dowson & Mason's Italian associates)



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Outside diameter	5.7 metres = 18′ 9″
Overall length	24 „ = 79′ 0″
Weight	220 tons

Total fuel oil consumption 5000 Kilos = 1250 gallons
Oil used per ton = 2.27 Kilos = 5.68 gallons
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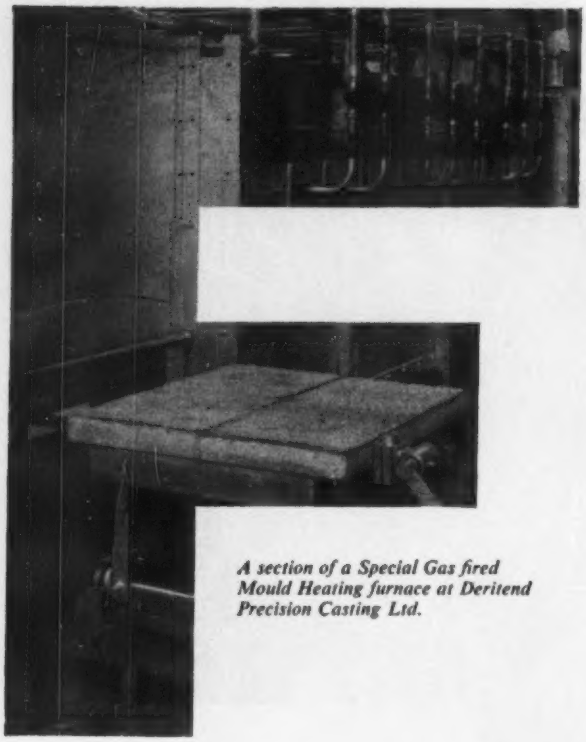

A section of a Special Gas fired Mould Heating furnace at Deritend Precision Casting Ltd.

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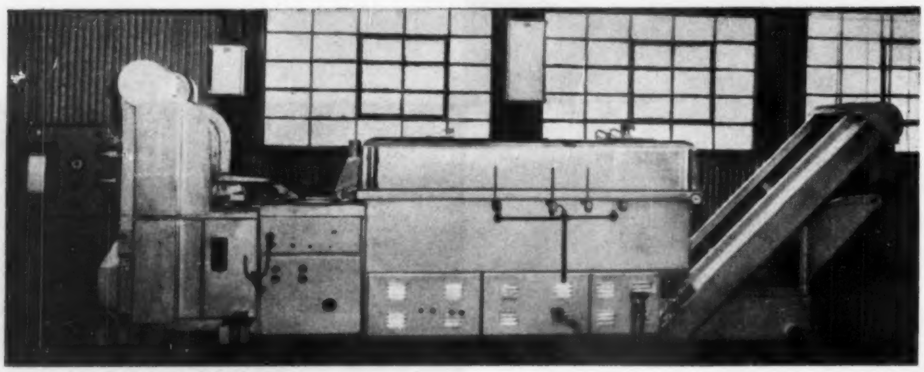

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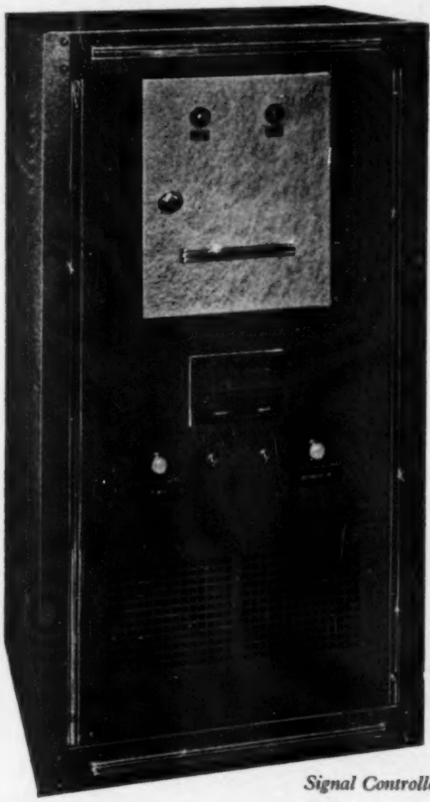

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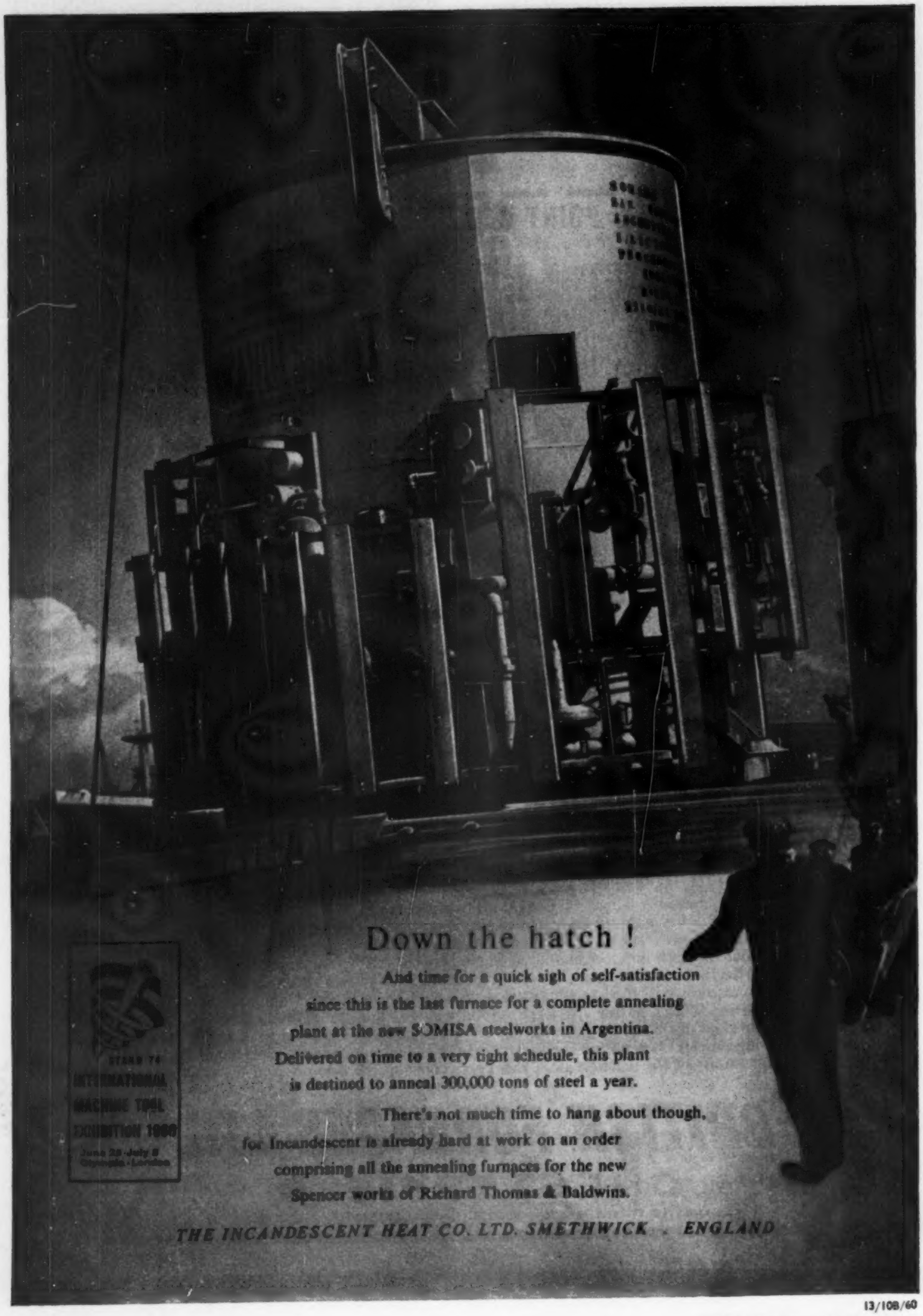
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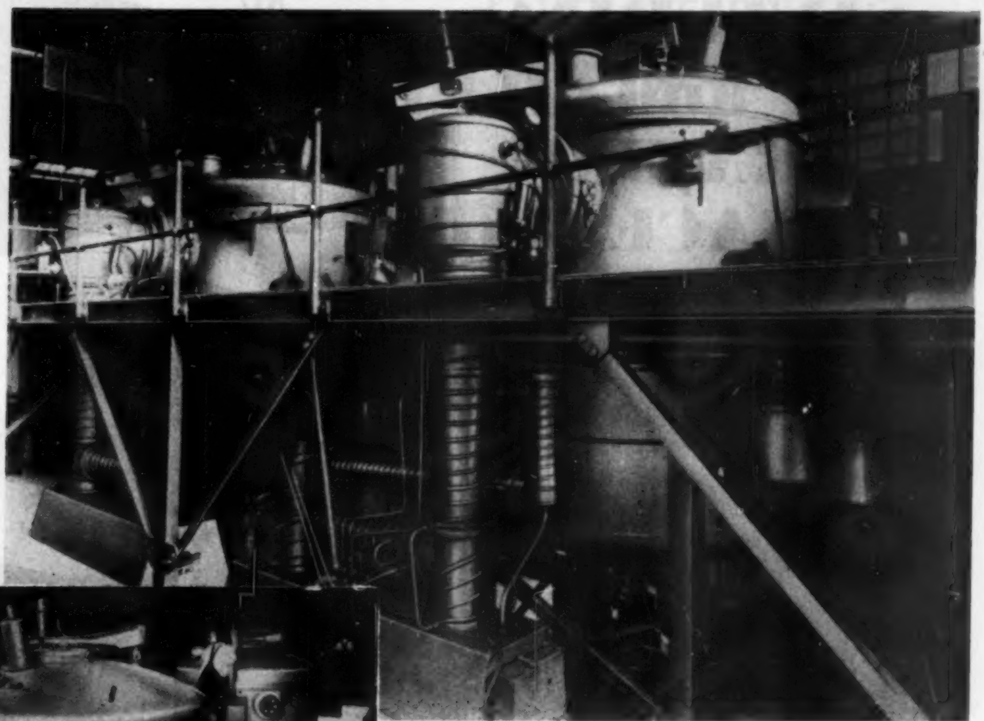

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The illustrations show :

Above : *Twin 5 cwt. capacity melting furnace for the production of special magnetic alloys, arranged for cyclic operation from one H.F. supply. (Photograph by courtesy of The Telegraph Construction and Maintenance Co. Ltd.)*

Centre : *Air tapping a 15 cwt. degassing furnace engaged in the manufacture of precision castings from almost 100 per cent. scrap material. (Photograph by courtesy of Sheepbridge Alloy Castings Ltd.)*

Below : *Melting and casting special steels on a pilot plant scale in a ½ cwt. vacuum furnace. (Photograph by courtesy of G. L. Willan Ltd.)*

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Mechanised Foundry in North Wales

Alleviation of Unemployment

Fig. 1.—Molten metal from one of the Birlefco mains frequency furnaces being poured into a special mould to form the plug of metal needed for starting up the furnace from cold.

IN an effort to alleviate unemployment caused by the reduced demand for slate, the Development Commission has, in recent years, sought to introduce new industries into the slate quarrying areas of North Wales. With this object in view, Austin Hopkinson & Co., Ltd. of Audenshaw, Manchester, manufacturers of Pikrose mining equipment, were encouraged by the Commission to site their new foundry at Penygroes, Caernarvonshire. In September 1957 a meeting was arranged between representatives of the company and of Wales and Monmouthshire Industrial Estates, Ltd., who had been requested by the Commission to act as agents for the erection of a new factory. It was agreed that the whole scheme should occupy 35,000 sq. ft. and in January 1958 the contract was awarded to William Cowlin & Son, Ltd., of Bristol.

Design of Buildings

With regard to the external appearance of the factory it was agreed that some consideration should be given to local materials. Accordingly, the lower part of the front wall, which faces roughly northwards at right angles to the main road (A4085), and one wall of the entrance hall were built in a green slate from a nearby quarry. These walls, with their rough-hewn texture of greens, browns, reds and yellows, are a handsome feature of the factory's architectural design.

In the factory building three working bays are provided ; one is for mould and core making, one for mould assembly and casting, and the third is a machine shop. A part of the works is equipped as a fabrication section where welded fabrications and steelwork for the main works are constructed. The bays are each 250 ft. long, 35 ft. wide and measure 20 ft. to the underside of the roof trusses. The building, which adjoins the office block, is of steel frame construction with 11 in. cavity walls. To give the necessary degree of thermal insulation, the asbestos cement roof sheeting is lined internally with ½ in. asbestos board backed with 1 in. of insulating quilt.

Under the terms of the agreement with Wales & Monmouthshire Industrial Estates, Ltd., Austin Hopkinson were responsible for the purchase of all equipment for the buildings, including cranes, melting furnaces, and sand plant. Additionally, all light fittings, power mains from main switches and internal wiring were the responsibility of the company. At a cost of £9,000, overhead travelling cranes of 3 tons capacity are provided in each of the three bays for handling heavy parts, castings, and ladles of molten metal. The maximum height of lift is 15 ft. 3 in. to the crane rail.

Casting Bay

With the exception of a gangway on each side and a finished area at each end, the floor of the casting bay was left in rough concrete 3 in. below the finished floor level, so that the main area could be filled with sand for casting purposes.

Two Birlefco mains frequency coreless induction melting furnaces (Fig. 1) are installed at the west end of the casting bay, the £26,000 furnace installation being used for melting iron and steel scrap for the production of castings for mining equipment components. High quality grey iron castings up to 1 ton and steel castings up to 10 cwt. are produced in the foundry, and can be supplied either as rough castings or in the finished machined condition. Each rated at 450 kW., the furnaces have nominal capacities of 30 cwt. They work alternately, and one furnace can be re-lined whilst the other is in operation. Not only does this arrangement permit day and night foundry operation, but it necessitates only one set of electrical gear.

Moulds are stored, cored and closed in the casting bay, where they remain until they are cast.

Moulding and Sand Handling

When planning production methods, local conditions were given chief consideration. Since a large proportion of the labour force was to be recruited locally, most of the employees would have no previous experience of foundry

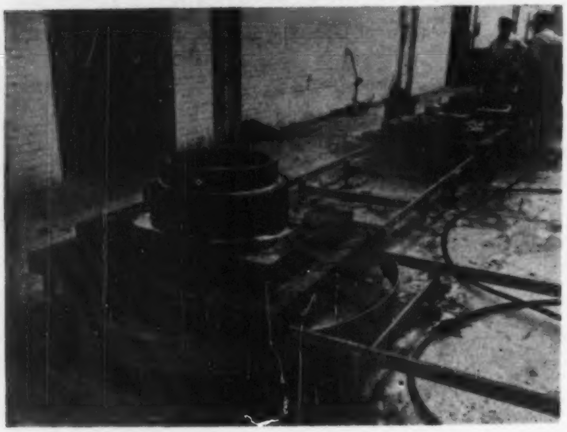

Fig. 2.—General layout and details of typical pattern assembly.

work. Consequently, much thought was devoted to the adoption of methods requiring minimum training and supervision. The services of Guthrie, Adams & Co. of Leeds were retained as foundry consultants on the entire scheme.

After close consideration, the foundry was planned and equipped for the production of castings solely by the CO_2 process, and about £23,000 was allocated for the complete sand plant. Sand of suitable grain size and low clay content is mixed with a sodium silicate solution of appropriate silica/soda ratio and viscosity, and the mixture is then rammed into core boxes or around patterns in the traditional way. The moulds or cores are then hardened by gassing with carbon dioxide. Hardening is extremely rapid, and casting may follow immediately afterwards, since no storing is necessary. A contract has been signed with the Billingham Division of Imperial Chemical Industries, Ltd., for the supply of Drikold solid carbon dioxide, and four Drikold liquefiers have also been installed to convert it into gas.

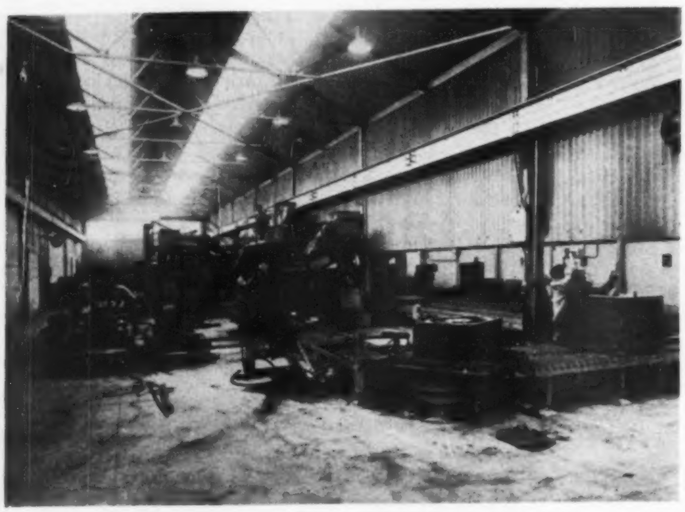

Fig. 3.—The moulding section of the foundry.

Though most of the castings made at Penygroes are consumed by Austin Hopkinson's main works at Audenshaw, the company also produces castings for the open market. Many are cast in batches up to fifty off, and they can, therefore, be handled on a semi-repetitive basis. Since all moulds and cores are made by the CO_2 process, all patterns and moulding equipment have been designed to utilise the process to the full, thus reducing the need for skill to a minimum on every operation.

Standardisation was also borne in mind when designing the moulding boxes and deciding pattern plate sizes. It was finally agreed to use only three sizes of moulding box, viz. 50×44 in., 44×34 in. and 36×30 in.: all patterns are made on single-sided boards to suit these boxes. In several cases it would appear that certain patterns could have been moulded more economically in smaller boxes, but this fact was overlooked because of the desire to limit the number of different sizes in use. As far as possible, the patterns have been designed and constructed so as to be self-moulding, thus reducing core-making to a minimum.

As the potential demand for castings was assessed at 200 tons per month, it was necessary to explore various systems of sand and mould handling and mould making, using the CO_2 process, and to choose the most adaptable system. It was finally decided to adopt the Nomad Pallet Conveyor System for handling the patterns and moulding boxes. This is manufactured by Hepburn Conveyor Co., Ltd., of Wakefield, who also supplied the following equipment: a sand slinger for ramming the moulds after the patterns had been faced with CO_2 sand; a rollover strip machine for stripping the patterns from the moulds and inverting the moulds; and a complete sand handling and conditioning plant, including a knock-out machine, screen, storage hoppers, mixers and belt conveyors. The complete sand handling plant was designed to suit the local layout, having an output of 15 tons per hour of backing sand to give a production rate of 80 complete moulding boxes per day. The knock-out and sand handling and treatment section incorporates a modern Pangborn Ventrijet wet dust collector.

The general layout and details of a typical pattern plate are shown in Fig. 2, and it will be seen that the pattern plates are carried on steel pallets which travel on rails. Pallets of this type were chosen in preference to roller conveyors for two main reasons: first, because the largest size moulds, including the patterns and sand, weigh over one ton and travel with much less effort and with a considerably smoother action than on normal roller tracks; and secondly, as the pattern boards are bolted on to the steel pallets, they are protected from damage caused by rough handling, or during turning over and stripping, and should therefore last considerably longer.

As only three sizes of moulding box are used, the pattern plates are required in only three sizes, all of which are accommodated on the standard size of steel pallet. These pallets are 53 in. square, and are drilled to take the pin centres of the three sizes of pattern plates and moulding boxes. The drilled holes are

used to fasten the pattern boards to the pallets with the aid of a collared pin which is bolted to the underside of the pallet. The pallet, which carries the pattern boards and mould-boxes, is so designed that when the unit reaches the rollover moulding machine it passes on to a specially designed table incorporating sections of the rail track and is automatically clamped there.

Fig. 3 shows the general layout of the moulding section and details of the conveyor track, turning tables, pallet and pattern arrangements. The rectangular shape of the track is designed to allow up to six pallets and pattern boards (three bottom boards and three top boards) to be in use at the same time. As it takes only a few minutes to change the pattern board on to a pallet, pattern changes are frequently carried out throughout the day.

The pattern and pallets awaiting use are stored on the long length of conveyor track, where they are faced with CO_2 sand. They are then moved in an anti-clockwise direction to the short side of the rectangular track, where the moulding box is located on the pattern board, as shown in Fig. 4. These moulding boxes have been returned from the knock-out grid by a short length of roller track. On this section any necessary lifters or gaggers are placed in position in the top halves of the moulding boxes. The assembly then passes along the second long length of track on which the moulds are completed by ramming with a sand slinger. All backing sand fed to the slinger is reconditioned and returned automatically by a sand conditioning plant.

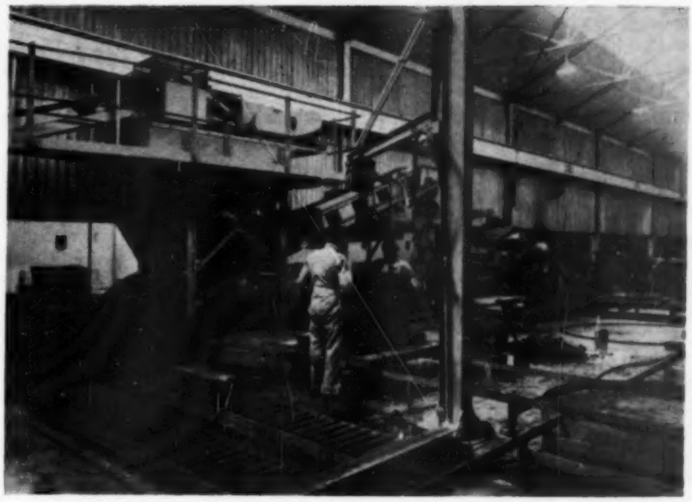

Fig. 4.—Locating the moulding box on the pattern board.

The rammed moulds then pass to the rollover machine table and are clamped in position. During the turnover operation, the moulding box is held in position by two beams placed across the bottom of the moulding box on to which four chains are fixed. The other ends of these chains are linked to a compressed air cylinder beneath the machine table. When the compressed air is applied, the chains automatically tighten and take the weight of the moulding box during the turnover operation. Simultaneously, this action reinforces the clamps holding the pallets on to the table of the machine. The pallets and pattern board are vibrated by a unit built into the table of the moulding machine and making contact with rapping blocks welded on to the underside of the pallets. It is therefore the pallets that take the wear and tear and not the pattern boards.

After the turnover operation, the chains are released and the beams removed so that the moulds are lowered away from the patterns. The moulds then pass on to the CO_2 gassing section. With good patterns and moulding tackle the moulds are such that there is no need for any finishing—in fact, this operation is strongly discouraged. The moulds are then gassed. A framed board is placed over the moulding box joint and gas enters the mould cavity through a hole in the board. The gassing time for all moulds has been predetermined and is controlled by a CO_2 gas flow-meter incorporated in the pipe line. After gassing, the moulds are lifted by overhead crane into the casting bay where, after they are blacked, cored and closed, they remain until casting.

When the pattern plates have been released from the rollover machine, the pallets return by the second short side of the rectangular track to the CO_2 sand facing section.

The existing plant is capable of meeting present demand, but provision has been made to duplicate the moulding section when required. The sand handling and conditioning plant is capable of dealing with this extension.

As originators of the scheme, Austin Hopkinson & Co., Ltd., have realised their intention to increase their capacity by equipping one of the most modern foundries in the country. All materials cast in the foundry are subjected to strict metallurgical control and analysis in a well furnished laboratory. The buildings are well appointed, and modern shower baths and canteens are among the facilities provided.

Powder Metallurgy Joint Group

THE next meeting of the Powder Metallurgy Joint Group of The Iron and Steel Institute and The Institute of Metals will be held at Church House, Great Smith Street, London, S.W.1, on Thursday and Friday, 15th and 16th December, 1960. One day will be devoted to a Symposium on "The Practical Aspects of Pressing Metal Powders," papers contributed to which will be printed, in advance of the meeting, in *Powder Metallurgy*, the half-yearly periodical of the Group. On the second day there will be discussions on papers which have been offered and accepted for printing in *Powder Metallurgy*.

The Committee of the Joint Group wish to emphasize that it is not their intention that Group meetings shall be restricted to the discussion of invited papers on particular themes; it is hoped that the meetings may, in fact, be devoted to the discussion of scientific and technological papers which have been submitted for publication without invitation. A leaflet detailing the preferred method of preparing MSS. of papers for publication may be obtained from The Secretary, Powder Metallurgy Joint Group, 17 Belgrave Square, London, S.W.1. Membership of the Group is international.

Magnesium Association in the U.K.

Joint Meeting with Magnesium Industry Council

According to the well-known clerihew, Sir Humphry Davy, besides "abominating gravy," "lived in the odium of having discovered sodium." What effect on his life and times his discovery and isolation of magnesium had is not disclosed by the clerihew writer, but there is no doubt that it has had a considerable influence on ours. It is just over a hundred and fifty years since Davy's discovery of the metal—called by him "magnium"—and some fifty years since the first Elektron alloys were commercially produced at Griesheim, nevertheless it is still regarded in some quarters as a comparatively new metal. It is probable that the replies to a public opinion poll question, "What does the word magnesium suggest to you," would reveal a considerable section of the population whose first reaction would be "medicine." Some of the more knowing ones would suggest "photography," "fireworks," or "incendiary bombs," but comparatively few would think of it as a material of construction. Even in the engineering industry it is not always given the consideration which its properties deserve. Nevertheless, the use of magnesium alloys is growing and the magnesium industry shows a quiet confidence about its future prospects. Corrosion is not the bogy it was and the fire hazard no longer provides a serious reason for not using magnesium alloys. At the Volkswagen plant, where more than four million magnesium castings have been machined, the shops and machines are kept clean and no trouble has been experienced in this regard.

As befits a comparatively new industry striving to expand, the magnesium industry is peopled by enthusiasts, whose ardour surmounts the barriers of nationality in the drive to secure for the metal its rightful place in the sun: in this sense one might rightly speak of a world magnesium industry. This unity of purpose was very much in evidence at the joint meeting of the American Magnesium Association and the British Magnesium Industry Council which was held in this country last month. In addition to American and British participants, many representatives of Continental producers and users of magnesium took part in what proved to be a most interesting and enjoyable programme.

London

The opening meeting was held at the Park Lane Hotel, London, under the joint chairmanship of Mr. Otis Grant, president of the Magnesium Association, and Mr. E. Player, chairman of the Magnesium Industry Council. This meeting was the occasion of the presentation to Major C. J. P. Ball of a plaque, featuring a line sketch of the recipient engraved on magnesium plate, in recognition of his outstanding contribution to the magnesium industry during many years of dedicated service. In making the presentation on behalf of the Magnesium Association, Dr. J. D. Hanawalt paid tribute to Major Ball's prophetic genius in working for the setting-up of a magnesium industry in this country prior to the last war. He also referred to the fact that Major Ball crossed the Atlantic ten times during the war in connection with the establishment at Henderson, Nevada, of a magnesium plant to Magnesium Elektron design. In expressing his thanks, Major Ball said that for the last thirty years magnesium had been his hobby as well as his work, and he had enjoyed every minute of it.

Following the presentation, Major Ball introduced the subject of world resources and production of magnesium and called upon the following speakers who discussed the position in their respective countries: Mr. J. Thomson (Canada), M. J. Gris (France), Herr W. H. O. Ziegler (Germany), Mr. T. Tangen (Norway), M. M. Perrochon (Switzerland), and Mr. W. J. Rave and Mr. E. Howard Perkins (U.S.A.). Whatever the method of production, there was general agreement that the scope for future expansion of the magnesium industry is closely linked with the ability to reduce costs so as to enable the metal to complete, particularly in the casting field, on at least equal terms with aluminium.

In the evening, the Magnesium Industry Council entertained those taking part in the meeting and their ladies at a banquet in the Park Lane Hotel. Sir Reginald Verdon-Smith (chairman of the Bristol Aeroplane Co., Ltd.) proposed the toast to the magnesium industry, and Mr. C. A. Howe (president-elect of the Magnesium Association) replied. Representing the Magnesium Industry Council, Mr. E. Player, chairman, proposed the toast to the guests, Mr. E. Howard Perkins, Jr., responding on their behalf.

Tuesday saw the start of the technical sessions, which opened under the chairmanship of Dr. C. J. Smithells, with Mr. S. G. Lind as vice-chairman. A general survey of magnesium wrought products in the U.S.A. and their applications was made by Dr. J. D. Hanawalt, who was followed by Mr. E. Howard Perkins dealing with military applications. The remainder of the morning session was devoted to a discussion of magnesium in the nuclear energy industry, Dr. E. F. Emley speaking on the U.K. programme and magnesium alloy requirements, and Mr. C. J. Smith on the production of magnesium components. In the afternoon, with Mr. C. A. Howe as chairman and Mr. T. Tangen as vice-chairman, two aspects of magnesium casting in the U.K. were considered, Messrs. R. W. Eade and B. W. Peck dealing with alloys and production and Mr. J. Pitman with commercial applications. The afternoon session concluded with a U.S. panel on magnesium as a Space Age material.

The Midlands

As a brief respite from their labours, members and ladies spent Wednesday travelling by coach to Stratford-on-Avon, taking in Oxford and Blenheim Palace at Woodstock on the way. The day concluded with a visit to the Shakespeare Memorial Theatre. Members and ladies were scheduled to spend Thursday night at Buxton, but whilst the ladies travelled there by way of Warwick and Kenilworth Castles, members visited either Sterling Metals, Ltd., at Nuneaton, or Birmetals, Ltd., at Quinton, near Birmingham. The latter is the main wrought fabricator of magnesium alloys in the

U.K., its products being sheet, strip, extrusions, tube, wire and forgings. Sterling Metals, on the other hand, pioneered the production of magnesium alloy castings in the U.K., and is today the largest producer in the country and one of the largest in the world.

Manchester

Friday was Magnesium Elektron's day, and on arrival at the works at Clifton Junction, near Manchester, two further papers were discussed at a technical session under the chairmanship of Major Ball, with M. J. Gris as vice-chairman. In the first of these papers, Mr. J. Kirkpatrick gave a profusely illustrated account of surface treatments and finishes for magnesium, and in the second the subject of pellet metallurgy in relation to magnesium alloys was discussed by Dr. R. S. Busk.

Magnesium production began at Clifton Junction in 1936 with an annual capacity of 1,500 tons, and was expanded during the war to a peak output of 9,000 tons per annum, but this is now greatly reduced owing to the high cost of electricity. The afternoon was devoted to a tour of the works, which include, besides the electrolytic extraction plant, ingot and D.C. billet casting foundries, research departments, an experimental sand foundry, a fabrication shop, powder plants, and plants for the manufacture of fluxes, master alloys and other metallurgical and chemical products

Those members and ladies staying the night in Manchester spent a very pleasant evening as guests of Magnesium Elektron, Ltd., at a dinner at the Midland Hotel, before departing for home or for further travels on the Continent.

Some Recent Annual Reports

B.I.S.F. — D.S.I.R. — N.P.L.

British Iron and Steel Federation

THE Annual Report of the British Iron and Steel Federation for 1959, shows that pig iron production this year should reach a record level of about 16 million tons; crude steel production should reach, and may pass, 24 million tons, a record figure some 20% higher than last year. The level of almost all finished products should increase considerably, with an especially substantial increase in steel sheet. If consumers build up stocks on anything like the scale of the 1955/57 period, then the industry may find itself hard put to meet all the demands made upon it.

Mr. Richard Summers, the President of the Federation, says in the foreword to the Report: "The experience of the last five years has shown the extent to which real swings in steel consumption can be magnified by the further changes in consumer stock policies which they provoke. Both the industry and its customers are hurt by these violent and unnecessary swings and both would benefit if ways could be found of moderating them." He also states that: "Despite the impact of the recession, capital expenditure in each of the years 1958 and 1959 was running at a rate of about £100 million. This year the industry expects to spend nearly a quarter more."

The industry is at present engaged in estimating the likely demand for its products in the sixties. A working party completed its report in January, 1960, and while the estimates are subject to possible reconsideration, it is likely that in the home market the consumers whose steel requirements should be expected to grow at a particularly fast rate are the motor and general engineering industries, especially those making consumer durable goods. The steel requirements of the coal mining and railway industries are expected to fall and the shipbuilding industry's requirements to rise comparatively little. In overseas markets the prospects for a growth in total direct exports of steel are expected to be favourable.

The President emphasises that: "It is clear that the sixties will bring a much more competitive steel market. As technical progress speeds up, steel will face a widening range of substitute materials, such as concrete, plastics and aluminium, but the British steel industry is confident that it can expand its markets in the face of this challenge. Recent developments in European integration will reinforce this trend towards more competitive markets. The new European Free Trade Association seems on balance to offer advantages, despite the heavier competition for some sections of the industry which it may bring."

Companies have been asked to give the Federation an indication of their future intentions as to modernisation and expansion. It looks as if the emphasis in the next phase of development will shift away from rapid overall expansion to ensure that the pattern of finished steel production is adapted to the rapid changes taking place in the economy and, secondly, that the industry must be even more closely concerned with efficiency of production and its costs. In the highly competitive nature of the steel market in the sixties cost efficiency will be the key to success.

In steelmaking in particular it looks as if the sixties will see a drastic change in the pattern of production with a marked growth of output from the new pneumatic processes and electric furnaces and with the use of oxygen as one of the primary steelmaking raw materials.

"Technical developments now under way," the President concludes, "should be able to bring stability or even a reduction in the cost of British steel over the next decade if the community at large is able to conduct its affairs with sufficient restraint to avoid a constantly rising general level of prices. The year ahead offers a high level of activity in the industry and the prospect of a record level of steel output."

D.S.I.R.

"THE nation's quickening interest in science and industry's growing participation in technological change make it more necessary for us to be ready for new responsibilities and to mobilise our resources of manpower, money and specialised equipment in the most effective manner for industry and the nation, faced as they are with stiff world competition," say the Council for Scientific and Industrial Research in their report for 1959—the first year of the Department's second five-year plan—pub-

lished last month.* "Above all," they add, "we must sustain the present acceleration of scientific and technical advance and see that progress is balanced between the needs of different industries and between important problems affecting the nation as a whole."

The report shows that in general it has been an active year of steady expansion and consolidation, and in the field of grants for researches and research training at universities and technical colleges the Council reports that the Department is giving much more support, with the full co-operation of the Treasury. During 1959 over 360 applications for research grants, totalling over £3,300,000 were received (compared with 204 applications, amounting to £1,350,000 in 1958). Of these, which include nuclear physics and human sciences, 295 (163 in 1958) were awarded, totalling £2,232,000 (£1,090,000). These grants, for the purchase of equipment and employment of assistants, and other aid, are normally spread over a period of 2–4 years. This strengthening of D.S.I.R. support to universities and technical colleges on a broad front—in every branch of science except mathematics the number of awards has been increased—is the first stage in the fulfilment of the Department's second five-year plan. In step with this progress is the expansion in the number of awards for postgraduate training. Research studentships rose by a fifth to 928 (777 in 1958), making a total of 2,144 studentships (new and continuing), compared with 1,681 in the previous year. Over 250 Advanced Course Studentships were awarded during the year, compared with 184 in 1958.

Following a survey of D.S.I.R. laboratories in previous years, the Research Council have recently reconsidered the broad aims and functions of the stations. As a result the Research Council have put before each station a limited number of clearly defined objectives "chosen so as to yield, if attained, the maximum national advantage from the resources available for research." The report clearly sets out the major purposes of the research stations and explains the redistribution of effort.

The Department is undertaking a series of economic and technical surveys of various industries, with their co-operation, one of the aims being to decide where research and development ought to be augmented and where support by the Department should be given consideration. An example is the recently completed survey of the machine tool industry. This threw up a number of important development projects which ought to be undertaken and these are now being studied, with the possibility of financial and technical support in view. When a project has been considered in detail by the Department, the results of the investigation are examined by the D.S.I.R. and the National Research Development Corporation. The N.R.D.C. may consider the project suitable for inclusion in its own programme, in which event the D.S.I.R. while maintaining its interest, would have no financial responsibility.

National Physical Laboratory

The wide range of research topics in modern physics covered by the work of the N.P.L. is described in the latest Annual Report of the Laboratory.† In the new Basic Physics Division the programme has been aimed at investigating different aspects of the physics of polymers, by means of the most modern techniques for examining the atomic structure of matter. Success in understanding how the atoms are held together in plastics and other polymers, and how these arrangements of the atoms define their mechanical, electrical and thermal properties would have far-reaching consequences. Only a beginning has been made so far.

New work is also reported from the C.M.E. Division, recently renamed the Autonomics Division. A start has been made on the problems of mechanical translation from Russian into English, using the ACE computer. Work of special interest to industry is concerned with methods for self-optimisation of industrial control processes; as a first example of this the operation of a distillation column is being simulated on a computer. The programme of the Aerodynamics Division covers many aspects of research of importance to future aircraft and missile design and development. The phenomena of buffeting and aileron buzz, which decrease the safety and controllability of aircraft when they occur, have been studied. As a result means of suppressing these effects have been suggested. On the non-aeronautical side, studies of the airflow around tall chimney stacks have suggested methods of eliminating "flutter." One successful idea is to wind helical "strakes" round the chimney.

The Standards Division has continued to foster international collaboration in several fields. In June last year the new international yard and pound already legalised by Canada and the U.S. were adopted for scientific purposes in this country. Determination of the density of mercury has been completed by measurements on samples from the standards laboratories of Australia and the U.S., and a start has been made on correlating U.K. and U.S. time and frequency services. The scale of temperature between 10°K. and 90°K. defined by the platinum resistance thermometer has been related to the thermodynamic scale by means of a helium gas thermometer. Comparisons are being made with the U.S. and Russia, with the intention of extending the International Temperature Scale below its present lower limit. Spectro-radiometric methods have been tried successfully by the Light Division for the first time in the establishment of the standard scale of colour temperature. Emphasis has also been given by the Division to improving diffraction gratings for metrological purposes in industry, particularly in association with manufacturers from the machine tool industry.

The Metallurgy Division, which is now equipped with some of the best modern research tools available for the study of metals (including an electron microscope, soft X-ray spectrograph, mass spectrograph and optical spectrograph), is bringing these modern techniques to bear on some of the problems associated with precipitation processes in iron. It is now possible, by using the electron microscope, to see dislocations (i.e. the faults in the atomic planes which weaken metals by one hundred to a thousand times). The new facilities for ship hydrodynamics research which were opened at Feltham by H.R.H. The Duke of Edinburgh last October, will allow studies to be made of the seakeeping properties of ships, and of the influence of hull shape, anti-roll and anti-pitch fins, etc., on the motion of ships in calm and rough waters. In conjunction with the Mathematics Division, the application of high-speed computers to ship design has been started.

* The Report of the Research Council of the Department of Scientific and Industrial Research published by Her Majesty's Stationery Office, price 4s. 6d. (81 cents U.S.A.) by post 4s. 10d.

† Report of the National Physical Laboratory 1959, printed for D.S.I.R. by H.M.S.O. price 8s. 0d., ($1.44 U.S.A.) by post 8s. 7d.

Mechanisation in Coin Manufacture

G.E.C. Vibrating Equipment installed at the Mint

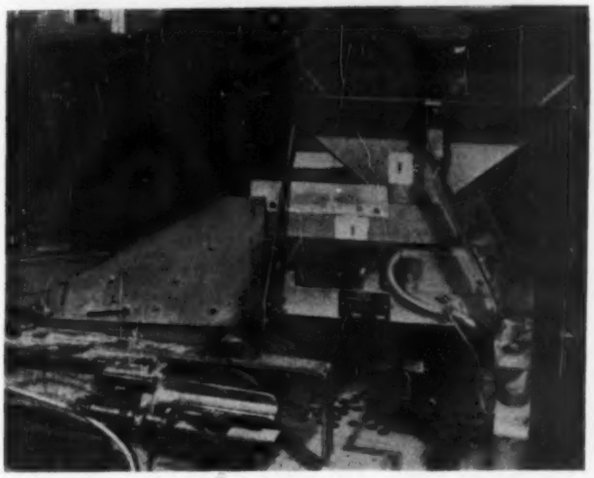

Fig. 1.—Hoppers are used to feed blanks on to an inspection conveyor.

THE Royal Mint is installing a large amount of Sherwen electro-magnetic vibrating equipment on some of the machines used in the manufacture of coins for countries in all parts of the world. This equipment, designed and manufactured at the Erith Engineering Works of The General Electric Co., Ltd., reduces the manual labour necessary in some of the operations involved. With the latest order, the total electro-magnetic vibrating equipment now on order, or supplied, comprises eighteen 9 in. by 14 in. and fourteen 3¼ in. by 17 in. Sherwen feeders, and fourteen 12 in. diameter Sherwen bowl-type feeders.

To appreciate the part played by the vibrating units, it is necessary to indicate briefly the nature of the minting process. The metal is received by the Royal Mint in its virgin state, either in the form of ingots (copper, tin, zinc, manganese and phosphor-copper) or in 5 cwt. drums (nickel shot). If required, silver and gold would be received in ingot form. After reception it is prepared in charges for the furnaces—in the correct proportions required for the type of money to be minted. There are four oil-fired and five high-frequency furnaces, the maximum temperature attained being 1,380° C., which is necessary for melting cupro-nickel, the alloy most commonly used for present day coinage.

The charge, which varies in weight depending on the alloy, is set at between 800 and 850 lb. for cupro-nickel. This, when molten, is poured from the furnaces into moulds to make bars of approximately 26 in. by 4 in. by 1 in. thick. These are then passed through several rolling mills and a final gauging mill which reduces the

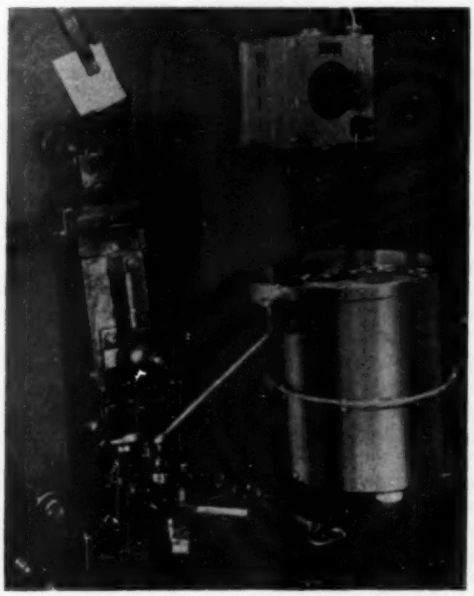

Fig. 2.—One of the presses fitted with bowl-type Sherwen feeder.

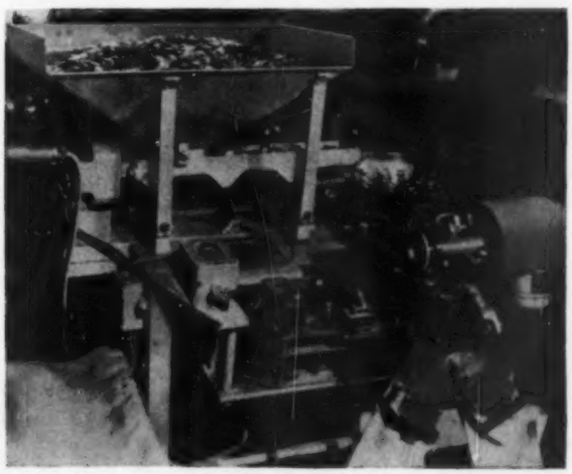

Fig. 3.—Counting of the finished coins is the final operation in the minting process. G.E.C. vibrating equipment is used on the telling machine.

alloy to the correct thickness. Due to the work-hardening effect caused by the rolling operations, annealing of the alloy is introduced at appropriate stages. The strips are next cut to the most economical length relative to the coin to be produced, and passed to the presses where the coin blanks are stamped out. A rough sorting, to eliminate imperfectly formed blanks, is then made on a sieve type of table.

Annealing of the coin blanks is followed by blanching in sulphuric acid followed by a solution of sodium bichromate. The acid is removed by water washing, and the blanks passed through rotary air driers. After this operation they are transported to the canneluring room, where the edge of each blank is compressed to form a raised rim. From here the blanks are passed to conveyors where visual inspection of both faces is carried out. It is at this point that some of the vibrating equipment supplied by G.E.C. plays an important part. In the past these conveyors have been fed manually, the coin blanks being emptied from bags on to ramps and directed on to the belt by hand. The ramps on all these conveyors have been replaced by hoppers and Sherwen feeders providing an automatic feed. The feeders were developed specially for this application and one is shown in Fig. 1.

If beading of the coins is required it is performed at this juncture, but otherwise the blanks pass to the press room, where the imprint on both faces and the milled edge (if required) is completed in one operation. There are fifty-three presses performing this function, and in the past the coins were placed in the feed tube by the operator. A changeover is now in process in which Sherwen bowl-type feeders are being fitted to the machines to enable the operator to give his undivided attention to the striking of the coins. So far ten presses have been converted to automatic coin feed while another four are in the process of being changed over.

Fig. 2 shows one of the presses, the coin feed and Sherwen bowl-type feeder being clearly visible. With the G.E.C. feeder shown, a bag of blanks can be poured into the bowl, these then being vibrated up the spiral which is fitted on the interior of the casing, and passed down into the coin-feeding cylinder. Each bowl is fitted with an electromagnetic vibrator rated at 0·375 kVA. 230 V., and the motion is transmitted to the bowl through sixteen mild steel flat springs.

The final operations in minting consist of weighing, overlooking and telling the finished product. Sherwen vibrating feeders are also fitted to these overlooking tables, while Sherwen vibrators assist in the handling of the coins in the telling room. Fig. 3 shows a telling machine equipped with a vibrator.

Sheffield Smelting Bicentenary

THE Sheffield Smelting Co., Ltd., was founded in 1760 by John Read who set up in business, in his own name, as a refiner. At this time silver and copper were bonded and worked together into all kinds of wares, now known as Old Sheffield Plate. The craftsmen who could manipulate plated metal found they could do the same with sterling silver. When working with metals the creation of scrap is inevitable, and silver scrap is valuable, but until the arrival of John Read there was no one in Sheffield able to recover the values from manufacturers' wastes. By 1782 Read had started smelting, appointed agents in London and Birmingham, and leased a 40 acre site near Royds Corn Mill, between Sheffield and Attercliffe. The business continued to expand, foreign agents being appointed and Read's nephew and two sons taken into partnership at the new works at Royds Mill.

Silverware and jewellery were increasing in fashion during the Victorian era, and the business made many improvements in the smelting and refining processes, including the installation of a plant for recovering the solids from furnace gases. The welfare of the workpeople was not ignored and in 1865 a bonus scheme was started, which continued, virtually without change, for more than eighty years. By 1890, when the company became incorporated, there were 112 employees, and a 48 hour week was introduced, and by 1894 a bath-house and dining rooms were provided. Holidays with pay were granted in 1900. Business expansion necessitated the acquisition of premises in Arundel Street, Sheffield, where rolling and wire-drawing equipment were installed to meet the increasing demands for silver in semi-manufactured forms. Many technical improvements were devised at Royds Mill, including the first plant to be installed in England for the refining of silver by electrolysis.

During the 1914–1918 war long hours were worked to fulfil contracts for copper, brass, cupro-nickel, silver/copper alloys and silver solders. The end of the war saw further extensions to plant and buildings at Sheffield, London and Birmingham.

The 1939–1945 war saw great changes in home market requirements. Government Supply Departments, Royal Ordnance Factories as well as many producers of munitions were the company's main clients. To meet the needs of peace time industry traditional activities have been greatly expanded and new ones added, including the production of non-ferrous ingots of the highest quality, made to strict specifications.

A difficult trading period in the 1950's called for reorganisation and the introduction of new policies. Under the present chairman, Robert Jardine, the company broadened its basis of trade, forming an agency in Italy and an associate company in Cairo, as well as acquiring subsidiary companies in London and Birmingham. The light engineering and electrical and allied trades fields come within the company's sphere as well as the production of thermocouple wires for the steel and other industries.

Gold and silver have always been used for articles of luxury and adornment, but nowadays their usage, along with the platinum group of metals, extends to much wider fields. Silver solders have become essential to the automobile, aircraft and engineering industries, whilst contacts of silver or other precious metals are in general use in electrical and electronic equipment.

From " one young man in a small town " the business, in terms of capital and employees, has grown into one of the biggest organisations in its class through the cumulative effort of the many people who have served it during the centuries, and much is in hand for accomplishment over the years to come.

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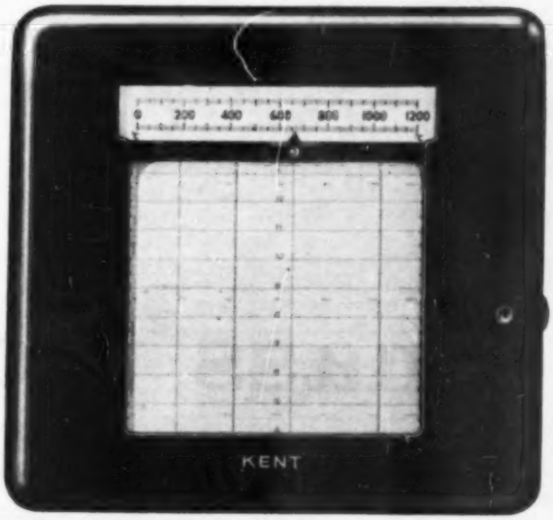

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NEWS AND ANNOUNCEMENTS

Die Casting Conference

THE Third International Pressure Die Casting Conference was held in Italy from May 16th to 20th, 1960. There was a record attendance of about four hundred delegates from twenty countries, including some seventy-five experts from the U.S., representing both the American Die Casting Institute and the Society of Die Casting Engineers. A message of goodwill from President Eisenhower was read by Mr. David Laine, Secretary of the A.D.C.I.

The European die casting industry has grown remarkably in recent years and Mr. R. L. Stubbs, Director of the Zinc Development Association gave the latest figures in the first paper presented at the Conference. The total European production of zinc die castings in 1952 was about 50,000 tons, and of aluminium just over 20,000 tons. By 1959 the figures had risen to nearly 120,000 tons for zinc and 85,000 tons for aluminium. British production of zinc alloy die castings—56,000 tons in 1959—was by far the largest in Europe; in aluminium, British and German production were approximately equal at 22,000 tons, France being a little behind them with 19,000 tons. At the end of the technical sessions, questions which had been submitted in advance were discussed and there was a useful exchange of views on vacuum die casting.

The Conference was followed by visits to the leading Italian pressure die casting works, which included tours of the Fiat and Olivetti plants as well as those of custom die casters. The papers and the full report of the discussions will be published later this year.

A.D.A. Director-General

THE Aluminium Development Association announces that General Sir Geoffrey Bourne, K.C.B., K.B.E., C.M.G., has been appointed Director-General to succeed Air Commodore W. Helmore, C.B.E., who recently retired after 14 years as Director-General of the Association. General Bourne has been A.D.C. General to the Queen since 1959. He was educated at Rugby and the Royal Military Academy, Woolwich, and was commissioned into the Royal Artillery in 1923. After a distinguished war record he became G.O.C. Berlin (British Sector) 1949–51 and was Commandant of the Imperial Defence College 1958–59. He took up his appointment with the Association in the middle of June.

Copper in Building

ON May 23rd, 1960, Dr. E. Carr, chief building engineer of the Copper Development Association, and his senior assistant, Mr. H. Glover, returned from a seven weeks tour of Canada and the U.S.A., where they had been studying at close hand the many applications of copper and its alloys in plumbing and building in these parts of the American continent. With an itinerary in which the climatic conditions extended from the sub-arctic to the sub-tropical, it was possible to make a most comprehensive survey of the use of copper and its alloys under these conditions, whilst the variety of buildings inspected ranging from conventional American frame houses to 82 storied sky scrapers, provided an extensive variety of plumbing applications.

During the tour Dr. Carr and Mr. Glover met and discussed matters of mutual interest with heating, plumbing, ventilating and air-conditioning engineers, architects and various employer and employee associations, including, particularly, the National Association of Plumbers and Pipe Fitters. Dr. Carr, as past President of the Institute of Plumbing, and also in view of the C.D.A. activities in this respect, was particularly interested in the American Association's approach to technical education.

Guest Keen Expansion Scheme

SINCE 1946 capital expenditure at the East Moors Works of Guest Keen Iron & Steel Co., Ltd., has amounted to some £13 million, and production capacity has increased from around 500,000 tons to 750,000 ingot tons a year. It is now proposed, in a comprehensive plan approved by the Iron and Steel Board, to spend a further £6·75 million to raise production of both iron and steel from present levels to make one million tons of ingots a year. This expenditure will be financed from group resources.

At present three out of four blast furnaces are operated, yielding some 610,000 tons of iron annually, the fourth furnace being a standby. The plant will be altered to enable all four furnaces to be blown simultaneously, as is current practice. This will give some 875,000 tons of iron and will enable the ironworks to keep pace with the needs of the steel melting shop. In the melting shop itself, production will be increased to a million ingot tons a year by the extensive use of oxygen in the open-hearth furnaces and the use of a larger ingot. Included in the development is the latest type of fume extraction plant, costing about £300,000 by which emission of smoke and dust will be controlled. In the mills extra rolling stands will be installed to enable the production of billets to be increased, both for use within the G.K.N. group and for sale outside the group. Ancillary services will be strengthened, including a new mould assembly and ingot stripping shop.

Refractory Makers' Centenary

A DINNER commemorating the centenary of the well-known Stourbridge refractories firm of E. J. & J. Pearson, Ltd., was held on May 7th at The Station Hotel, Dudley, and was attended by some 150 members of the staff and their friends. The ceremony was presided over by Mr. R. E. G. Evers, chairman of the company who was supported by the directors and their wives. After dinner a message of greeting from Col. C. W. Thomas, C.B.E., who has been a director of the company since its incorporation in 1898, was read by Mr. R. A. Pearson. Col. Thomas regretted that infirmity at the ripe old age of ninety-three prevented him from being present in person, but he sent hearty greetings and best wishes for a successful evening.

The toast of " E. J. & J. Pearson " was eloquently proposed by Mr. W. J. Price, who is chairman of the holding company Price-Pearson Refractories, Ltd., and of the associate company J. T. Price & Co., Ltd. Mr. Price drew attention to the remarkable expansion achieved by E. J. & J. Pearson, Ltd., in its century of growth. In his reply, the chairman gave an interesting

historical review, based on early documentary evidence and on recollections provided by Col. C. W. Thomas. A number of humorous as well as more serious incidents in the history of the concern were related. Mr. Evers paid tribute to the late J. W. Thomas, father of Col. C. W. Thomas and a man of exceptionally outstanding character who had served the company well in the latter years of its existence as a partnership and for the first few years after its incorporation as a company. Mr. Evers also referred to the long period of over half a century during which the fortunes of the company had been in the hands of his late father, Mr. Guy Evers, and of Col. C. W. Thomas. He stated that despite wars, slumps, fires and strikes the company had gone from strength to strength, and he illustrated this with a number of interesting statistics.

The toast of " The Staff " was felicitously proposed by Mr. C. A. G. Thomas, whose recollections of earlier days were received with great interest. Mr. J. C. Marriott, a senior representative of the company replied appropriately.

During the evening souvenir glassware was distributed. This consisted of coloured glass dishes taken from a print on a calendar issued by the firm in its earliest years, and will be treasured by the recipients as an interesting and artistic memento of a memorable occasion.

Foundry Refresher Course

A Refresher Course on Developments in Foundry Practice will be held in the Metallurgy Department, Battersea College of Technology, from July 19th to 22nd, 1960. The course has been designed to survey the progress and developments in both processes and equipment on a wide front, and to indicate the possible significance of these developments. Lectures by a panel of visiting specialists from the foundry industry will cover the following topics: technological and managerial developments in the foundry industry; developments in permanent mould practice; developments in sand mould practice; precision casting today; foundry equipment, and future possibilities in the foundry. There will be ample time for discussion of each topic and it is hoped to arrange some suitable visits to foundries.

The fee for the course is £12 12s., (inclusive of luncheon, morning and afternoon refreshment, and visits). Enrolment forms and further information may be obtained from the Secretary (Metallurgy Courses), Battersea College of Technology, London, S.W.11.

Aluminium in Railway Rolling Stock

A Symposium on the Use of Aluminium in Railway Rolling Stock, organised jointly by the Institute of Locomotive Engineers and the Aluminium Development Association, was held on Friday, May 27th, at the headquarters of the Institution of Mechanical Engineers.

The Symposium was opened by Mr. R. G. Smeddle, president of the Institution of Locomotive Engineers, who also acted as chairman for the first session, at which five papers on design and construction were briefly presented for discussion. At luncheon, Mr. W. Brinning, president of A.D.A. introduced the guest of honour, Dr. R. Bennets, M.P., chairman of the Parliamentary and Scientific Committee. It was a source of gratification to the organising bodies that the guests included a number of chief mechanical engineers and other representatives from overseas. The afternoon session, presided over by Mr. Brinning, comprised eight papers dealing with operation and service experience.

"Research" Essay Competitions

The Scientific Advisory Board of *Research* have decided to continue the Waverley Gold Medal Essay Competition this year, in the belief that the clear presentation of scientific material in a form readily understood by both scientists working in other fields and by laymen is of great importance.

This year a new " Application in Industry " essay competition is also being introduced, which is designed to draw attention to the difference between a purely scientific solution and a practical commercially viable project. Candidates, who must be practising scientists under the age of thirty, are invited to write an essay of some five thousand words discussing the commercial exploitation in the next decade of any new idea, concept or experimental result put forward in the recognised scientific literature in the last two years. The first prize for the new competition is £50 and the second £30.

The closing date for both competitions is July 31st, 1960: further particulars can be obtained from the Editor of *Research*, 4/5 Bell Yard, London, W.C.2.

Personal News

The Minister of Power has appointed Mr. A. J. Peech deputy chairman and general managing director of The United Steel Cos., Ltd., to be a part-time member of the Iron and Steel Board in place of Mr. N. H. Rollason.

Mr. H. H. Utley has been appointed managing director of Davy and United Roll Foundry, Ltd. Mr. M. A. Fiennes, previously chairman and managing director has thus relinquished the managing directorship but remains chairman. After service with the United Steel Cos., Ltd., the Skinningrove Iron Co., Ltd., and Dorman Long and Co., Ltd., Mr. Utley joined Davy and United Roll Foundry, Ltd., as director and general manager in 1957.

George Kent, Ltd., announce the appointment to the board of directors of Mr. J. F. Willsher, general works manager. Mr. Willsher joined the company in 1947 and held the post of Instrument Division manager from 1955 until early 1959, when he succeeded the late Mr. J. Horridge as general works manager.

West Instrument, Ltd., the temperature control instrument manufacturers, have announced the appointment of Mr. H. McGlyn as quality control engineer at their Brighton factory.

The board of directors of the Croda Organisation, Ltd., announce that Mr. F. A. S. Wood has been elected chairman to succeed the late Sir Edward Crowe, K.C.M.G. Mr. Wood retains his position as managing director of the company. The board also elected Mr. N. Townend a director of the company.

Wickman, Ltd., announce the appointment of Mr. C. F. Watts as a director of the company. Mr. Watts joined the company in 1945 and was appointed secretary and later financial controller.

Lord Fraser of Lonsdale has been elected chairman of Capper Pass and Son, Ltd., in succession to Mr. A. D. Pass who announced last October his intention to retire from the chairmanship and who remains on the board.

RECENT DEVELOPMENTS

MATERIALS : PROCESSES : EQUIPMENT

Portable Electric Mould Driers

By an agreement with Brown Boveri and Co., Ltd., of Switzerland, the Electric Resistance Furnace Co., Ltd., are to manufacture portable electric mould driers of the Brown Boveri design in three ratings—25, 70 and 140 kW., and in two temperature ranges up to 350° C. and up to 650° C., for grey-iron and non-ferrous foundries and steel foundries, respectively.

These driers are widely used in foundries on the continent for drying floor moulds and large box moulds. They operate by forcing hot air not merely over the mould surface but through the sand itself. It is claimed that, using air temperatures some 100°–150° C. lower than the hot gases from fuel stoves, and less than one third the quantity of heat, they have reduced drying times by a half, and in some cases by two thirds. The heating is uniform throughout the mould and, despite the rapid drying, mould surfaces remain free from cracks and cleaner castings are produced. The driers need no attention during operation, the power input being regulated automatically to maintain the desired air temperature. Working conditions are improved by the elimination of smoke and burning gases. Large cores can be inserted in the moulds and dried at the same time, the castings then being made without re-opening the moulds.

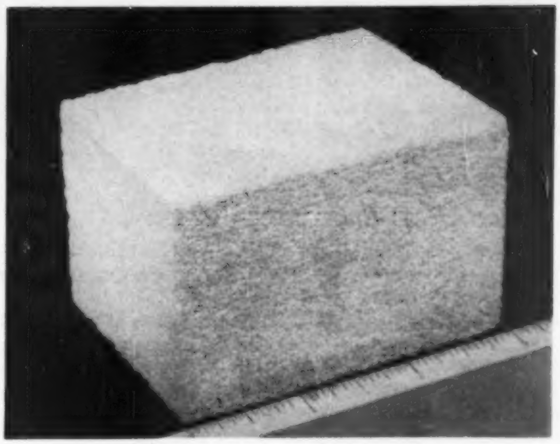
The drying equipment consists of an electric air heater, a fan and driving motor, and control gear, all of which is assembled into a single compact unit. The air is heated by being passed at great speed through ceramic tubes containing spiral-wound heating elements. The fan is fitted with a radially-bladed impeller and a suitable diffuser, the impeller being mounted on a specially strengthened motor shaft. The motor is completely enclosed to protect it from dust and moisture. A single switch is used to bring the drier into operation and to adjust the power input. The air temperature is controlled by a pointer-type mercury thermometer, with minimum and maximum contacts, which switches elements on and off as necessary. A manometer measures the static pressure in the mould and indicates the density of the mould and the porosity of the sand.

A mould to be dried is covered as for casting and the drier is placed in position over the casting gate. All openings with the exception of the core and coke bed ventilation channels are closed. With the drier in operation, hot air is forced through the mould sand where it gives up its heat and passes out through the ventilation channels saturated with steam. The absence of steam indicates that drying has been completed.

Electric Resistance Furnace Co., Ltd., Netherby, Queens Road, Weybridge, Surrey.

High Temperature Insulating Brick

Ipsen Super Alloyed ceramic material used successfully for radiant tubes, furnace fans, and thermocouple protection tubes has been joined by a companion material of

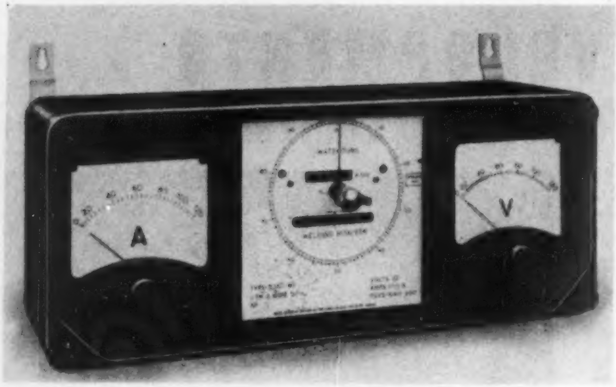


extreme refractoriness which has been made into a high temperature lightweight insulating brick. This ceramic brick was developed by the Ceramic Division of Ipsen Industries, Inc., and is made in convenient brick size of $2\frac{1}{2} \times 4\frac{1}{2} \times 9$ in. The formulation of aluminium oxide material is expanded and then fired, to create a cellular structure in which all cells are interconnected. Thus, its absorbent property permits gas to pass through for purging or evacuation. Although it has the density of a 1,600° F. (870° C.) insulating firebrick, and an insulating value comparable to a 2,300° F. (1,260° C.) insulating firebrick, the new brick can be operated up to 3,400° F. (1,870° C.), and it can readily be cut, sawed, or filed. It has a wide range of application in the nuclear, metallurgical, chemical, and aeronautical industries. In the high temperature metallurgical field it has found immediate acceptance as a lining for hydrogen furnaces, for vacuum processing, and as a catalyst support in generators.

Ipsen Industries, Inc., 715 South Main Street, Rockford, Illinois, U.S.A.

Welding Meter

A new meter for A.C. welding production, research and development is announced by English Electric. Designed to measure the electrical conditions in a welding arc, it can be applied in costing, calculating efficiency, developing electrodes and improving production techniques, e.g. in determining the ideal cooling rate for various metals. The unit consists of a watthour meter, ammeter, voltmeter and protective relay all housed in a compact case ($16\frac{1}{2} \times 5\frac{3}{4} \times 6\frac{1}{4}$ in.), suitable for switchboard or wall mounting. The user can thus see at a glance the arc voltage and current and the total energy being consumed. The relay is incorporated to give protection against over-current in the event of the meter being used with an incorrect current transformer ratio. A four-range current transformer for stepping down the current from 100, 300, 500 or 1,000 A. to 5 A. can also be supplied. This gives a wide variation on the welding currents that can be



accurately recorded. The meter is also suitable for other manufacturing processes where energy consumption over short periods has to be measured.

The watthour meter has a pointer which moves over a 4 in. diameter scale, one revolution of the pointer being equivalent to 100 Wh. at 100/5 A.: for other ratios a multiplying constant must be used. The pointer can be re-set to zero after each welding operation by depressing the knob in the meter glass and turning anti-clockwise: the total watthours are shown on the meter register. The ammeter and voltmeter are of the 4 in. square moving-iron pattern, and zero adjusters are accessible through cover plates in the meter window. The voltmeter is scaled 0–120 V. and is marked 1 V. per division between 20 and 45 V., the normal arc voltage range. The ammeter is scaled 0–120 A. and reads direct for a current transformer ratio of 100/5 A. As for the watthour meter a constant must be used for other ratios. The relay is re-set by a push rod on the underside of the case.

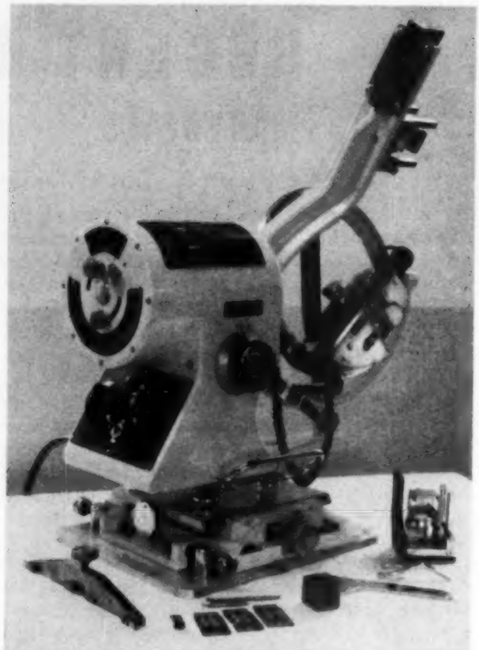
The English Electric Co., Ltd., Marconi House, Strand, London, W.C.2.

Multiplane Diffractometer

A NEW multiplane diffractometer for fully automatic or manual operation has been designed and produced by Seton Creaghe Engineering, Ltd. It is based on a design currently in use at the Atomic Energy Research Establishment at Harwell, and it is claimed that its new features make it the most advanced and versatile instrument in its field. Apart from its use in the nucleonics field, it is of particular value in the chemical, mining, minerology, semi-conductor, welding and metal industries, and in universities where research in crystal structure analysis is constantly being carried out.

The Seton Creaghe instrument, which weighs approximately 75 lb., incorporates goniometric and scanning movements fulfilling the requirements of rapid operation and extreme accuracy. The diffractometer is an X-ray instrument designed to use the Schulz method of determining the preferred orientation of crystals. This method enables the intensities of reflections to be related, without correction, to the number of crystals reflecting. By this method the instrument can be used to examine the crystal structure of a specimen in any plane by the simple but precise adjustment of the goniometer ring.

The main body of the instrument is carried on adjustable cross slides by three levelling screws and can be further adjusted in angle to the base. The geiger counter



arm and goniometer ring are carried by concentric bearings and the gearing between them gives a 2 : 1 angular movement. The goniometer ring can be adjusted separately in relation to the counter arm and then clamped. Rotation of these items is by hand and two scales give the 2θ angle to one minute of arc.

Slit systems are provided for the incident and reflected beam. These are accurately located and various angles of beam spread can be provided. Since the slit system is arranged in a simple geometric ratio, careful choice of slits can double the range of receptor and divergence angles.

The goniometer has a scale inscribed to $\frac{1}{2}°$ and carries the specimen holder and a beam width limiting slit. The width limiting slit provided as standard is for preferred orientation, and a special curved slit can be supplied for purely diffraction purposes. The specimen holder can be rotated and reciprocated in the beam by two variable speed motors: the angle of specimen rotation and length of stroke being shown on scales. Specimen holders for rod, sheet or tube specimens are available.

The setting up of the instrument is rapid and no re-adjustments are needed when the plane of examination is altered. Gauges are provided to position the specimen accurately, and seven simple adjustments are all that are needed to prepare the instrument for use. Metallurgists at Harwell have already made intensive use of this type of device and the Secray instrument makes possible a considerable saving of time and a considerable increase in the amount of information obtained. Tests have shown that the diffractometer is capable of separating an a_1, a_2, doublet less than 6′ apart.

Seton Creaghe Engineering, Ltd., is also producing an X-ray camera which will be particularly suited for work in conjunction with the diffractometer.

Seton Creaghe Engineering, Ltd., G. W. Trading Estate, Park Royal Road, London, N.W.10.

CURRENT LITERATURE

Book Notices

PHYSICAL AND ENGINEERING PROPERTIES OF CAST IRON

By Dr. H. T. Angus, Deputy Director of The British Cast Iron Research Association. Fully bound, gold blocked cover, 9¼ × 7in., 528 pp. Published by the B.C.I.R.A., Bordesley Hall, Alvechurch, Birmingham. £2 12s. 6d. to members of the Association; £3 13s. 6d. to non-members ($11 in the dollar area).

In the long history of cast iron much has been written on the metallurgy and applications of the material; engineers and designers frequently find it necessary to consult a large number of works to obtain information they require. In the 500 pages of "Physical and Engineering Properties of Cast Iron" there is assembled a wealth of information on the behaviour and properties of cast iron, and the way in which they are related to its engineering applications. The book originated in a private collection of data which the author acquired over a wide range of industrial experience and from problems submitted to the Development Department of the British Cast Iron Research Association. Almost every item of information included in the book has been requested at some time or another. It is hoped, then, that the accumulated experience contained in "Physical and Engineering Properties of Cast Iron" will be of great practical value to those who are dealing with the day-to-day problems of ironfounding and engineering as well as to research workers, technical colleges and technical reference libraries.

The book is divided into nine parts: constitution and structure; mechanical, physical and electrical properties; general properties of commercial cast irons; special properties affecting surface, such as heat and wear resistance, machinability, etc.; heat treatment of grey cast iron; internal casting stresses; components with high local loadings; cast iron beams, columns, pipes, cylinders and pressure vessels. The last part is devoted to the application of specifications and data to design. The text is well illustrated with nearly 150 plates, diagrams and graphs, and supporting data are presented in convenient tabular form. There is an excellent selection of references to original and standard works, and the index makes it easy to find specific information.

STANDARD X-RAY DIFFRACTION POWDER PATTERNS

By Howard E. Swanson, Marlene I. Cook, Thelma Isaacs and Eloise H. Evans. National Bureau of Standards Circular 539, Vol. 9, 64 pp. Order from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., 40 cents (foreign remittances must be in U.S. exchange and should include an additional one-fourth the publication price to cover mailing costs).

The X-ray Powder Data File, a compilation of diffraction patterns from all sources, is used for the identification of unknown crystalline materials by matching spacing and intensity measurements in the patterns. Under a project sponsored by the Joint Committee on Chemical Analysis by Powder Diffraction Methods (American Society for Testing Materials, American Crystallographic Association and British Institute of Physics), the National Bureau of Standards is contributing to the growth and improvement of the general File. This circular, the ninth in the series entitled "Standard X-ray Diffraction Powder Patterns," presents 43 patterns, of which 31 are replacements for 41 patterns already represented in the X-ray Powder Data File, and 12 are for substances not previously represented. These patterns were made with a Geiger counter X-ray diffractometer, using samples of high purity. Comparison is made of all powder diffraction data available for each of the substances reported. Each section of the circular contains structural data, lattice constants, calculated densities, and a table comparing indexed "d" values and intensities presented by N.B.S. with existing powder patterns available in the literature.

Trade Publications

Until comparatively recently, 40-ton arc furnaces were the largest built in Europe, but there is now a trend towards larger units able to compete with the open hearth furnace in the production of carbon steel. An article on "Larger Arc Furnaces for Melting Shop and Foundry," by Mr. W. J. Kelsey of Metalectric Furnaces, Ltd., appeared in the September 1959 issue of *The British Steelmaker*. This has now been reprinted and is available from the company.

"Forging in Magnesium Alloys" is the title of a new booklet issued by High Duty Alloys, Ltd. Technical information is given on three magnesium alloys, namely Magnuminium 133 and 133X, which are magnesium-manganese alloys, and Magnuminium 266, a magnesium-aluminium-zinc-manganese alloy. Details are also given of the magnesium-zinc-zirconium alloy ZW3, manufactured under licence from Magnesium Elektron, Ltd. In the second part of the booklet are illustrated typical die forgings in magnesium alloys.

One of the principal articles in the Spring issue of *Copper*, the Copper Development Association publication, bears the title "How the Copperbelt orebodies were formed," the story of which begins some 600 million years ago. Written by W. G. Garlick, Consulting Geologist to the Rhodesian Selection Trust Mine Services, Ltd., it presents a fascinating account of the geological changes which have taken place over the centuries. Other articles deal with the spark machining process, in which copper and brass have recently assumed the role of cutting electrode materials; electronic valves; copper alloys and copper-containing alloys used in cutlery; and factors affecting the performance of condenser and heat exchanger tubes.

A quotation from Descartes—"Nothing can contain nothing"—appears as the title of an article in the April issue of *Efco Journal*, in which the author traces man's ideas on "vacuum" from the Ancient Greeks to the present day. Other items in this issue include an article on precision taper roller bearings and their heat treatment; short features on oil heated elevator furnaces and the automatic heat treatment of bearing rollers; and brief descriptions of foundry equipment made by Sinex Engineering Co., Ltd., whose foundry products are now being marketed exclusively by the new Foundry and Metallurgical Equipment Co., Ltd.

We have received from Graphite Products, Ltd., Northfields, Wandsworth Park, London, S.W.18, a copy of a new publication (G.P. 59/60) dealing with Foliac colloidal graphite for the lubrication of drop forging dies. Reference is made to such topics as die life, the pretreatment of dies, and the types of dispersion available. Among the advantages claimed for graphite die lubrication are: appreciable increase in life; reduction in surface friction to allow good die filling; complete freedom of the forging in both top and bottom dies; ease of application; absence of explosions and clean working conditions.

It is now more than thirty years since the continuous rolling of wide strip became a fact in the United States, and during this period there have been many advances in the technique of rolling, in outputs and in quality. Most of these have been achieved by changes in the layout and the equipment installed in the hot mill. As soon as it became evident that a number of new installations of this type were to be made in the U.K. and other European countries, Davy and United Engineering Co., Ltd., set about the task of establishing the many factors involved in the design and layout of a modern hot strip mill. The conclusions reached as a result of investigations to this end are presented in Vol. 1, No. 4, of *Davy-United Engineering* recently produced by the company.

We have recently received from George Kent, Ltd., a number of new publications. No. 988 deals with Commander flow measuring instruments of the recording, indicating, integrating, controlling, and transmitting types for use in conjunction with orifice plates and fittings, Venturi tubes, Dall tubes, Dall orifices and Pitot tubes. The Commander boiler-test indicator—for measuring steam turbine condensate flow and boiler feed water flow to official boiler test standards—forms the subject of Publications 365, whilst primary elements for temperature measurement by resistance thermometers, thermocouples and radiation pyrometers are discussed in Publication 349. Finally, Publication 150 is concerned with an old established Kent activity, the manufacture of instrument panels of the plate and unit types.

The new Kodak Industrial X-Ray Catalogue provides, in easy-reference form, information about the salient features, sizes, prices and stock availability of Kodak industrial X-ray materials and equipment. The items detailed include X-ray films for industrial radiography; materials for reproduction of radiographs; materials for autoradiography; radiation monitoring film; processing chemicals; and exposure, processing and viewing equipment.

In order to provide an alternative bag filter suitable for less arduous duties than the recently introduced Holmes-Retroflux design, the Gas Cleaning Division of W. C. Holmes & Co., Ltd., have commenced manufacture of Holmes-Standard bag filters. These are designed to handle heavy dust burdens at an efficiency in excess of 99% for all particles, including those in the sub-micron range. Publication No. 83, which describes these filters can be obtained from the company at Turnbridge, Huddersfield.

Marconi Instruments, Ltd., have done much pioneer work in measuring *p*H. At the end of the war two laboratory *p*H meters were available, the battery-operated TF 511D and the mains-operated TF 717A. These were followed by a direct reading type, the TF 889. The latest addition is a full-range instrument, the TF 1093, in which all the experience gained over the years has been used to construct an equipment for which exceptional accuracy and stability are claimed, and which has facilities for scale expansion and full temperature compensation applied automatically. An article on this development is featured in the March issue of *Marconi Instrumentation*, along with others on an electronic counter and on apparatus designed for telegraph signal distortion-analysis.

The new British Standard B.S. 3189 : 1959, "Phosphate Treatment of Iron and Steel for Protection Against Corrosion," which has been authorised by the Iron and Steel Industry Standards Committee of the British Standards Institution, has now superseded PD 539, "Recommendations for Phosphate Coatings as a Basis for Painting Steel." It provides specifiers of phosphating systems with a suitable basis on which to work, so that now there can be throughout industry the same standard of treatment in the five classes of phosphating processes, both accelerated and unaccelerated, with which the new British Standard is concerned. In a leaflet recently issued by the Paints Division of Imperial Chemical Industries, Ltd., the I.C.I. Granodine treatments suitable for the classes of coating detailed in B.S. 3189 and in Defence specification DEF 29 are set out, and an indication of the applications for which each is suitable.

A booklet giving technical data on thermal insulation has been produced by Stillite Products, Ltd., it is intended to form a guide to those who wish to estimate heat losses and temperature gradients in insulated systems without having recourse to the kind of data which is sometimes issued by insulation manufacturers in tabular form. Such tabular matter is usually intended as a general guide only, and often falls short of requirements. Cases often arise where, for one reason or another, a departure from normal standards is indicated, and the formulae and methods of procedure given in the new booklet will enable calculations to be made for most conditions, provided the basic data, such as thermal conductivity at the appropriate mean temperatures, are known. Copies are available from the company's head office at 15 Whitehall, London, S.W.1.

Books Received

"Jahrbuch der Schleif- und Poliertechnik, 1960." 419 pp. Essen, 1960. Vulkan-Verlag Dr. W. Classen. DM. 16.

"Zone Refining and Allied Techniques." By N. L. Parr. Foreword by E. J. Vaughan. 184 pp. inc. index and numerous illustrations. London, 1960. George Newnes, Ltd. 40s. net.

"Cemented Carbides." By Dr. P. Schwarzkopf and Dr. R. Kieffer, in collaboration with Dr. W. Leszynski and Dr. F. Benesovsky. 349 pp. inc. subject and author indexes and numerous illustrations. New York and London, 1960. The Macmillan Company. $15.00 or 105s.

"The Directory of Opportunities for School Leavers, 1960." Preface by the Rt. Hon. Sir Oliver Franks, G.C.M.G., K.C.B., C.B.E. 212 pp. London, 1960. Cornmarket Press, Ltd. 8s. 6d. net.

"Beryllium." By G. E. Darwin and J. H. Buddery. Metallurgy of the Rarer Metals, No. 7. 392 pp. inc. index. London, 1960. Butterworths Scientific Publications. 70s.; by post 2s. extra.


B.E.R.L

LABORATORY METHODS

MECHANICAL · CHEMICAL · PHYSICAL · METALLOGRAPHIC

INSTRUMENTS AND MATERIALS

JUNE, 1960 Vol. LXI, No. 368

Titrimetric Determination of Antimony

By M. R. Thompson, B.Sc.

The earlier literature relating to the titrimetric determination of antimony has been reviewed by Gibbons.[1] The present article considers work which has been published in the intervening years. For the convenience of the reader, methods have been grouped according to the titrant used in the determination.

IN order that antimony may be titrated oxidimetrically the metal must be present in the trivalent state, and consequently numerous reduction procedures have been recommended from time to time, the more important being sulphur dioxide,[2] potassium iodide[3] and sodium hypophosphite.[4] More recently Johnson and Newman[5] proposed the use of iodine and red phosphorus as reducing agent before determination of the antimony iodimetrically. Yoshimura[6] claimed that a zinc amalgam in potassium hydroxide (2N) will reduce quinquivalent antimony in three minutes in the presence of sodium pyrophosphate. It is important, however, to exercise careful control over the alkalinity, because in a less alkaline solution the reduction with zinc amalgam proceeds much more slowly.

Bromatometric Procedure

The bromatometric procedure for the determination of antimony was first described by Györy;[7] since that time it has received much attention and there has been some controversy as to the optimum working conditions. Györy,[7] himself, used methyl orange to detect the end-point in a solution of normal acidity, but he made no reference to temperature. Later workers have preferred various temperatures and acidities and in addition a number of indicators, both reversible and irreversible, have been recommended for use in this titration. In their modified semi-micro method for the determination of antimony in type-metal, Yavorovskii and Shimanskii[8] used a warm antimony^{III} solution for titration against potassium bromate (0·1N), methyl orange being used as indicator. Brown, Forshaw and Hayes[9] also used potassium bromate to determine antimony in antimony-lead alloys. These workers employed sulphur dioxide to reduce the antimony and preferred methyl red to detect the end-point of the titration. Szekeres, Sugár and Pap[10] claimed an error of less than $\pm 1 \cdot 0\%$ when titrating antimonyl potassium tartrate with bromate, using starch-iodide paste as reversible indicator. Yoshimura,[6] however, used indigo carmine to detect the end-point when he titrated antimony^{III} with potassium bromate.

Liteanu and Máthé in their study of irreversible redox indicators have examined, photometrically, the titration of arsenic and antimony with bromate. The oxidation of antimony with bromate is represented by the equation :—

$$3\,Sb^{3+} + BrO_3^- + 6H^+ \longrightarrow 3\,Sb^{5+} + Br^- + 3H_2O.$$

In their first paper,[11] these workers considered the influence of the concentration of bromide ions, hydrogen ions and hydrochloric acid, and also the effect of light on the speed of decolorisation of both methyl orange and methyl red indicators when employed in the bromatometric determination of antimony. They found that for a sharp end-point the concentration of hydrochloric acid should lie between 6 and 10%, but at that concentration decolorisation of the indicator occurred before the end-point was reached, and consequently it was found to be necessary to employ potassium bromide to delay the decolorisation. These workers then showed that the antimony^{III} concentration should be adjusted so that the bromide ion concentration resulting from the reaction was not greater than 0·031 moles per litre. Liteanu and Mathe preferred methyl orange to methyl red, owing to its greater solubility in water and to the more rapid discharge of the colour at the end-point. In a later publication, Liteanu and Mathe[12] showed that the accuracy of the bromatometric titration of antimony is determined by the speed of the two reactions :—

(1) $Sb^{3+} + Br_2 \longrightarrow Sb^{5+} + 2Br^-$

(2) Coloured indicator + Br_2 ⟶ decolorised indicator.

If reaction (2) is faster, then the indicator end-point will be reached before the equivalence point, but if this reaction is slower, then the reverse occurs and the equivalence point is reached prior to the decolorisation of the indicator. These authors have demonstrated that, with methyl orange as indicator in a strongly acidic solution, the speed of decolorisation decreases with increasing acidity and with increasing bromide concentration. A correct end-point is only obtained if the product $[H^+]^5\,[Br^-]$ lies between 0·4 and 1·2 at the end of the titration. In view of this fact, in their later work Liteanu and Mathe preferred to use indigo carmine in place of methyl orange as indicator in the bromatometric titration of antimony, since the former permits the pH of the solution to be varied over wider limits.

Jilek and Nederost[13] have modified the Evans[14] method of determining antimony and arsenic in white metals and antimony sulphide ores. They treated a hydrochloric acid solution of the metal salts with sodium hypophosphite in order to precipitate the arsenic. Hydrogen sulphide was then bubbled through the filtered solution and the precipitated sulphides removed. Antimony sulphide was dissolved in concentrated sulphuric acid and the antimony^{III} determined by titration with potassium bromate (0·1N). Alternatively, these workers determined arsenic on one aliquot with sodium hypophosphite, before titrating the total arsenic and antimony bromatometrically on a second aliquot, following a sulphide precipitation and subsequent solution in concentrated sulphuric acid. The antimony content of the material under test was then found by difference.

Detmar and van der Velde[15] have devised a bromatometric method for the determination of antimony in lead- and tin-base alloys which employs a potentiometric titration. The sample was dissolved in brominated hydrochloric acid and titanous chloride used to reduce the antimony^{V}. Any titanium^{III} and copper^{I} present following the reduction were reoxidised, using sodium vanadate in hydrochloric acid (2N). This oxidising agent, which does not react with antimony^{III}, was added dropwise at room temperature whilst the course of the reaction was followed by means of a potentiometer. The antimony^{III} was then determined bromatometrically using a potentiometric end-point. These authors claim that, under these conditions, lead, tin, copper, bismuth and arsenic do not interfere, although iron, if present in appreciable amounts, has to be removed. The report that copper does not cause any interference is most doubtful in the light of other experience. Chlebovsky[16] has shown that the influence of copper can be eliminated only by separation prior to the determination of antimony by titration with potassium bromate.

Hamlin[17] has devised a useful indirect bromatometric method to determine antimony in the presence of copper and iron in textile materials. He destroyed the organic matter by wet ashing with a mixture of nitric, sulphuric and perchloric acids. Precipitated antimony was redissolved in boiling hydrochloric acid and a reduction with titanous chloride carried out, the excess reductant then being determined by titration with potassium bromate. Chlebovsky[16] also reported, what many other workers have found, that in the presence of large amounts of lead, adsorption of antimony^{III} occurs when the lead is removed as sulphate. He recommended, therefore, that the lead sulphate should be redissolved in hydrochloric acid and the antimony determined on the resulting solution. It is preferable, however, to avoid the sulphate separation of lead and to employ the alternative chloride/alcohol procedure. Another more attractive proposition is to separate the antimony by a method of solvent extraction. Morrison and Freiser[18] have listed the various extraction procedures.

Hypochlorite and Permanganate Methods

Khatun and Khundkar[19] claimed that the potentiometric determination of tripositive antimony with alkaline hypochlorite is superior to the bromatometric titration. From their results they showed that under optimum conditions antimony can be determined with an error of less than $\pm$ 1·0%. The titration with aqueous sodium hypochlorite is carried out at 80°–85°C., using a platinum electrode *vs.* S.C.E. system.

Titration with potassium permanganate to determine antimony has been preferred by a number of workers. Some disagreement as to the optimum conditions of acidity and temperature to be used in the titration, in order to obtain maximum accuracy, has been recorded. Potassium permanganate acts as its own indicator, of course, except in very dilute solutions, when a potentiometric finish is to be preferred. Issa and El Sherif[20] used a potentiometric method when determining antimony on the micro scale. They prepared a solution of antimony^{III} (*ca.* 0·0001N) which was 0·1N in respect of sodium hydroxide and to which was added 1g. of telluric acid. The solution was titrated with potassium permanganate (0·0002N), added in 0·05 ml. increments, and the reaction followed potentiometrically. Using this procedure these authors claim that 3μg. of antimony can be determined with an error of less than $\pm$ 5%. In a later publication,[21] the same authors showed that the oxidation of trivalent antimony with alkaline permanganate and subsequent backtitration with univalent thallium gave good results in the presence of telluric acid when the hydroxyl concentration was less than 0·5%. If tartrate was present, however, a higher hydroxyl concentration could be tolerated. They showed, in this latter paper, that antimony^{III} in the higher concentration of 0·67–13mg. can be determined with an error of less than 0·55% by adding the sample solution dropwise to a permanganate-telluric acid mixture in sodium hydroxide solution (1–2N) and back-titrating the excess with thallium^{I}.

Mambetov and Guseinov[22] have shown that the permanganate method of determining antimony is unsuitable when the precipitation of antimonic acid or the release of free chlorine occurs, and they have therefore devised a procedure whereby neither of these phenomena can take place. At high acid concentrations, interference in the permanganate determination of antimony occurs, and consequently Ecke[23] recommended addition of the Zimmermann-Reinhardt preventative solution. Leeman[24] considered also that this expedient gave a much improved end-point. Mohr[25] in his determination of antimony in copper alloys, however, added only manganese sulphate to overcome this interference, and he titrated the antimony solution with permanganate in the cold.

Ceric Sulphate Titration

Another titrant which is used frequently in the titration of trivalent antimony is ceric sulphate, which was first proposed by Willard and Young[26] who determined the end-point potentiometrically. Since that time many dyes have been put forward as suitable indicators, and recently Petzold[27] has claimed that methyl red is a superior indicator to methyl orange. Petzold showed that in the determination of antimony in forensic samples containing tartaric acid, the concentration of hydrochloric acid must be carefully controlled when ceric sulphate is used as titrant. In the presence of 3% tartaric acid accurate results are only obtained if 20–25% (v/v) concentrated hydrochloric acid is present. However, in the absence of tartaric acid, he recommended the use of a solution which was only 17–22% in respect of concentrated hydrochloric acid.

Iodimetric Method

Gooch and Gruener[3] were the first workers to determine antimony by titration with iodine. The reaction can be represented :—

$$Sb_2O_3 + 2I_2 + 2H_2O \rightleftharpoons Sb_2O_5 + 4HI$$

The reverse reaction is prevented by the removal of the hydriodic acid by means of excess alkali, usually sodium bicarbonate. End-point detection is normally carried out using starch indicator, although Pevtsov[28] recommended the use of indigo carmine when determining antimony in the presence of tin. Johnson and Newman[5] used the conventional starch indicator when they determined antimony iodimetrically after reducing the antimony with iodine and red phosphorus. Bachelder and Sparrow[29] however, detected the end-point potentiometrically when they carried out the determination of antimony present in indium antimonide. Lingane and Bard[30] also claimed that an electrometric procedure was superior to the conventional starch end-point when they determined antimony using electrogenerated iodine. Quantities of antimony^{III} ranging from 0·06 to 10mg. were titrated in a phosphate buffer (0·1M) of pH 8 that was also 0·1M in respect of potassium iodide and 0·025M in potassium tartrate. Errors from $-0{\cdot}6\%$ to $+\ 0{\cdot}8\%$ were recorded for the method. Two papers have been published recently describing iodimetric procedures for the determination of antimony in the presence of other metals.

Verma and Singh[31] developed a procedure for the determination of antimony in the presence of copper. They used alkaline citrate to complex the copper before the antimony was determined by titration with standard iodine in neutral solution. The method is rapid and can be applied over a wide range of antimony concentrations. Suzuki and co-workers[32] devised a method of determining antimony in the presence of any two of the three ions, arsenic, tin, iron, by varying the pH of the solution and by the use of masking agents. Iodine oxidises only tin quantitatively in acidic solution, arsenic in weakly acidic or neutral solution and iron and antimony in an alkaline/fluoride solution. Since iron can be masked conveniently by citric acid, antimony may be determined in its presence.

Miscellaneous

A number of other titrimetric methods have been recommended from time to time for the determination of antimony. Recently, Shat'ko[33] devised a laborious procedure in which antimony metal was precipitated by reduction with chromium^{II} in a neutral or weakly acid medium. The antimony was filtered off and oxidised in the presence of dilute sulphuric acid with excess of potassium dichromate (0·1 or 0·2N). The excess dichromate was reduced by addition of a slight excess of ferrous iron, and the excess ferrous iron determined with potassium dichromate after the addition of phosphoric acid and diphenylamine indicator. Shat'ko claims that arsenic does not interfere and that the method is sensitive to 0·05 mg. of antimony in 100 ml. Cíhalík[34] reported that iodine monochloride was a suitable reagent for the titrimetric determination of antimony in a weakly acidic or weakly basic medium on a semi-micro scale. He determined the end-point both visually, using starch indicator, and potentiometrically, and he found that the average error was of the order of $\pm\ 0{\cdot}3\%$. Richter[35] described an instrument for automatic coulometric titrations involving an amperometric end-point which, in the titration of antimony^{III} with electrogenerated bromine, gave an error of the order of only 0·2%.

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New Analysis Equipment For Mond

Over the past thirty years the policy of The Mond Nickel Co., Ltd., has been to devote a large part of its energies and expenditure to the maintenance of a highly organised development and research service. The company's Birmingham laboratory is probably the largest and best equipped research organisation in its field in Europe, and the acquisition of new and up-to-date equipment is a high priority.

In June this year, the department took delivery of one of the first models of a new automatic X-ray fluorescence spectrometer, manufactured by Solartron, which carries out non-destructively precise measurement of the constituents of an alloy exceeding 0·1%. More recently, a solids mass spectrometer, the first commercially produced machine of its kind in the world, has been installed. This equipment, supplied by Metropolitan-Vickers, analyses for all elements in the Periodic Table down to one part in 100 million. These two instruments together provide a unique combination of sensitive and accurate analysis over a wide range of compositions.

Steels For Nuclear Power Plants

Contributions from Canada, the U.K., the U.S.A., and the U.S.S.R. are expected for a symposium on " Steels for Nuclear Reactor Power Circuits," being organized by The Iron and Steel Institute. The topics to be discussed will include: factors governing selection of steels; fabrication aspects; irradiation effects; high-temperature properties; corrosion; and steels for future reactors. The symposium will be held at the Hoare Memorial Hall, Church House, Great Smith Street, London, S.W.1, from Wednesday, November 30th, to Friday, December 2nd, 1960.

Bureau of Analysed Samples, Ltd.

Triennial Meeting of Co-operating Analysts

A RECORD number of over eighty analysts, representing all branches of the metallurgical industry, Government departments and research association laboratories attended a meeting in York on Tuesday, 10th May, arranged by Bureau of Analysed Samples, Ltd. After an introductory welcome by Dr. E. Gregory, Mr. P. D. Ridsdale, the managing director, gave a report on the progress in the preparation of British Chemical and Spectrographic Standards during the three-year period to November, 1959. His report stated that during this period five new standards have been issued, *viz:* No. 280, a refined ferro-manganese; No. 290, a 13% manganese steel; No. 301, a Lincolnshire iron ore; No. 302, a Northants iron ore; No. 303, an iron ore sinter; and that the preparation of the following eight new chemical standards is now in progress: a 10% aluminium bronze; a 6% zinc-aluminium alloy; a 75% ferro-silicon; a magnesium alloy containing zinc and rare earths; a Nimonic 90 alloy; a 0·4% carbon free-cutting steel; a chromium ore; and a sillimanite refractory.

The chromium ore and the refractory samples are being prepared at the request of the British Ceramic Research Association and the 0·4% carbon free-cutting steel at the request of the Association of Drop Forgers and Stampers.

In addition to work on new samples, replacements of no less than 36 standards have been prepared and issued during this period. These include 3 carbon steels, 3 alloy steels, 3 cast irons, 4 ferro-alloys, 2 basic slags, 1 iron ore, 3 aluminium alloys, 2 non-ferrous alloys, 7 pure metals, and 8 low alloy steels. Mr. Ridsdale also announced that work on a further ten replacement samples is in progress, and that since the end of last year three of these have been completed and will be issued shortly, *viz:* No. 239/2, a 0·3% carbon steel; No. 163/1, a 1·2% carbon steel; and No. 183/1, a bronze containing 3·5% Pb and 0·5% P. Mr. Ridsdale mentioned that standardisation of this bronze sample had given a number of laboratories an opportunity to try out several of the draft British Standard methods for the analysis of copper alloys which had been circulated to industry for comment, and that the results obtained had proved that nearly all these methods are very satisfactory.

Spectrographic Standards

Turning to spectrographic standards Mr. Ridsdale reported that a new series of low alloy steel spectrographic standards had been issued to replace the original series which was now exhausted. This new series is issued in the form of both the 1 in. square section bars and 1¾ in. diameter discs to meet the requirements of the spectrograph and all forms of direct reading instruments, including vacuum direct readers. Work is also nearing completion on a new series of plain carbon steel standards for direct reading instruments. This series which is being standardized for carbon, silicon, sulphur, phosphorus, manganese and arsenic, will be supplied in the form of 1¾ in. diameter discs for spectrographic work, but will also be available in the form of turnings for chemical analysis.

Probably the most important development in the field of spectrographic samples is a new series of cast iron standards for magnesium and nickel which will be available in the near future. This series, which is being prepared in conjunction with the British Cast Iron Research Association, will cover the range of 0·005–0·015% Mg and 0·35–1·4% Ni and will only be available in the form of 1·2 in. diameter bars for spectrographic analysis.

A steadily increasing demand both at home and abroad for chemical and spectrographic standards was reported, and the fact that these standards have been exported to no less than fifty different countries during the last three years gives an indication of the world wide recognition which they receive.

Mr. Ridsdale concluded his report by thanking all the analysts who had co-operated in the analytical standardisation of these samples. The meeting was then thrown open for general discussion during which comments on existing samples and suggestions for new standards were put forward. A printed report giving details of the proceedings will be issued and will be available on request from Bureau of Analysed Samples, Ltd., Newham Hall, Middlesbrough.

European Federation of Corrosion

THE British Association of Corrosion Engineers has been elected a member of the European Federation of Corrosion. The object of the Federation, which is a non-profit making union, is to promote European co-operation in the field of research on corrosion and methods of combating it for the benefit of the community at large. Membership of the Federation is restricted to non-profit-making European technical and scientific societies whose activities are connected with the field of corrosion or the protection of materials.

The Federation seeks to achieve its objects by convening joint European meetings for the discussion of subjects of general interest: by convening meetings of working parties for the discussion of specific problems; by the creation of working groups for investigating special problems; by the organisation of study trips; and by other means. The General Secretariat of the Federation is managed jointly by the DECHEMA in Frankfurt a.M. and the Societe de Chimie Industrielle in Paris.

The British Association of Corrosion Engineers was formed last year generally to promote the dissemination of technical information about corrosion matters; to develop the free interchange of information among members; and to promote such educational and other facilities as may be required for the establishment of corrosion engineering as a recognised profession. Individual membership (two guineas a year) is open to everyone interested and associated with corrosion engineering. The address of the Hon. Secretary is 97, Old Brompton Road, London, S.W.7.

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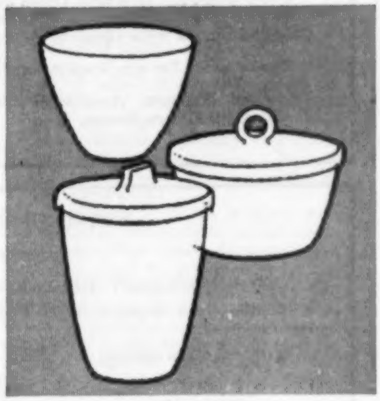

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Physical Metallurgist is required for the Research Laboratories of Firth Brown Tools Ltd. Applicants should be under 30 years of age and possess a Degree, or equivalent qualification, in Metallurgy. The work involved will largely be concerned with powder metallurgy but will also embrace problems of research connected with the manufacture of Engineers' Cutting Tools. Salary will be in accordance with age, experience and academic standard attained. Apply in writing to the Labour Manager, Speedicut Works, Carlisle Street East, Sheffield, 4.

NATIONAL PHYSICAL LABORATORY (D.S.I.R.), Teddington, Middlesex, requires Scientific Officer/Senior S.O. inorganic chemist to investigate concentration and separation techniques, including solvent extraction and ion exchange in collaboration with team developing physical methods for analysis of high-purity materials. Facilities available for radio-isotope studies and activation analysis. Quals.: 1st or 2nd Class Hons. degree or equiv. in Chemistry. For S.S.O. at least 3 years post-grad. experience required. Salary: (men) S.O. £655–£1,150. S.S.O. £1,233–£1,460. Forms from Ministry of Labour, Technical and Scientific Register (K), 26, King St., London, S.W.1, quoting reference F.364/OA. Closing date 25th July, 1960.

SITUATIONS VACANT—*continued*

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28 Theobalds Road, London, W.C.1.

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Salary £A1,540/£A2,040 p.a. Salaries are at present under review.

Further particulars are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

Applications close in Australia and London on 16th July, 1960.

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Full particulars of the course may be obtained from the Head of the Department of Chemistry, Metallurgy and Textiles.

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